United States Court of Appeals

for the

District of Columbia Circuit

TRANSCRIPT OF RECORD

No. 9399

BRIEF FOR APPELLANT [redacted]

IN THE
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DISTRICT OF COLUMBIA

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for the District of Columbia
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ALONZO L. SMITH,
Appellant

v.

CASPER W. OOMS, COMMISSIONER OF PATENTS
Appellee

Appeal from the District Court of the United States for the District of Columbia

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United States Court of Appeals

DISTRICT OF COLUMBIA

No. 9399

ALONZO L. SMITH,
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v.

CASPER W. OOMS, COMMISSIONER OF PATENTS
Appellee

Appeal from the District Court of the United States for the District of Columbia

BRIEF FOR THE APPELLANT

JURISDICTIONAL STATEMENT

Suit is brought by Alonzo L. Smith of Houston, Harris County, Texas, as Appellant in his own right. This appeal is the result of the filing of an application for patent by the Appellant on September 20, 1941 for his invention in a Well Surveying Device and Method, Serial Number 411,761, some of the claims of which were refused by the Commissioner of Patents, Appellee herein. From such refusal, the Appellant filed a Bill of Complaint (Joint App. pp. 3-10) against the Appellee-Defendant Commissioner of Patents, in accordance with the provisions of the Federal Laws of the United States as provided for by Revised Statutes, Section 4915. The Appellee herein filed an Answer (Joint App. pp. 10-11) upon which issue was joined and trial was had. The Honorable District Judge rendered a statement including Findings of Fact and Conclusions of Law, (Joint App. pp. 12-14) and rendered judgement thereon (Joint App. p. 15). From such decision the Appellant filed a notice of appeal within the period prescribed by Rule 10 of this Court and duly filed a statement of points on appeal (Joint App. pp. 15-16) so that this appeal comes before the Court of hearing.

STATEMENT OF THE CASE

Alonzo L. Smith, an individual residing at Houston, Texas, conceived a new and useful invention in a Well Surveying Device and Method, and filed an application for United States Letters Patent thereon on September 20, 1941, which is identified as Serial Number 411,761. Such application was duly prosecuted before the Primary Examiner of the Patent Office and the subject matter thereof treated in three separate and distinct divisions, namely, Division 32, Division 48, and Division 62, due to the fact that no one division would accept the invention as being classified in its particular division, so that the Appellant was compelled to respond to three different grounds of rejection, one by each of the three divisions. All three of the divisions refused to allow the claims sought by the Appellant and an appeal was taken to the Board of Appeals on or about March 23, 1944. Three Examiners' statements were filed, one by each of the Primary Examiners, which statements are in evidence as Appellee's Exhibit J (Joint App. pp. 98-102), Exhibit K, (Joint App. pp. 103-109), and Exhibit L (Joint App. pp. 109-117). The Board of Appeals rendered a decision thereon on March 22, 1945, reversing the Primary Examiner's rejection as to claim 7 of the Appellant and sustaining the Examiner as to the remaining claims in the application. The Appellant then petitioned reconsideration of the decision of the Board of Appeals and such petition was denied on April 25, 1945 by a Memorandum Decision, Appellee's Exhibit N (Joint App. pp. 122-123).

The invention relates to a method an apparatus for surveying or obtaining information in the drilling and completion of wells by the rotary method. In the rotary method of drilling the bit is rotated and mud circulated therethrough and upwardly in the well to wash away the cuttings. After drilling is completed an electrical survey is made with a view of detecting elevations from which oil or gas may be produced. A string of pipe or casing is then set in the well and cemented in position. A gun to discharge bullets to perforate the casing and open the well at the elevation at the production formation is then lowered into the well. Great difficulty was encountered in completing the well in this manner because very often the circulating drilling mud washed away the softer formations and created an enlarged area in the well bore. The softer sand formations are usually the ones which always produce oil or gas. When the well was cemented to anchor the casing, the cement moved into this large washed out area to form a thicker layer of cement about the casing at the elevation of the washed out formation. The bullets from the perforating gun often failed to penetrate this thick layer of cement and the well was abandoned as a non-producer because the operator did not appreciate that he failed to get a well because of the lack of penetration of the excessively thick layer of cement due to the enlarged area.

The foregoing is standard practice in the art. It was also standard practice in the art to lower a diameter measuring instrument into a well bore to detect variations in diameter so as to be able to compute the amount of cement which it was necessary to pump into the well to cement the casing.

The Appellant Smith conceived the idea of combining an electrical logging instrument which was well known and a diameter measuring or calipering instrument together so that they could be operated as a single instrument in a single operation so that the placing of a thick layer of cement in the productive formation could be avoided. The combining of these two instruments provided a simultaneous reading which would assure the operator that it was the productive formation which had been washed out and the hole become enlarged. This combination of the two instruments to obtain an accurate and simultaneous reading is entirely novel in the art. Where the instruments were previously run separately each on a wire line cable, many errors occurred due to the stretch in the cable and inaccuracy in measurement and the inability to coordinate the readings. The operator thus could therefore never be sure that two indications, one on each log, were at the same elevation because the readings as to elevation were taken at different times, by different operators, on different cables. The Smith contribution was therefore assurance of accuracy by combining the electrical logging instrument and the caliper or diameter measuring instrument into a single unit to take accurate simultaneous readings.

Another feature was the fact that the accurate diameter reading would indicate an additional thickness of drilling mud in the well bore which in turn affected the electrical logging readings and the operator, with Smith's combination instrument, can then correct his electrical log for the variation in the size of the well bore. The Smith invention also disclosed a procedure for spacing the cement below and above the enlarged area so as to insure the gun perforator bullets penetrating the casing and opening the formation. The sole ground of refusal of these claims is that the combination of the electrical logging instrument and the caliper diameter measuring instrument together to obtain a new and useful result lacked invention.

STATUTES INVOLVED

The applicable statutes are as follows:

REVISED STATUTES, Title LX:
Act of Mar. 2, 1927, 44 Stat. L. 1335
Act of May 2, 1929, 45 Stat. L. 1476

"Sec. 4915 (U.S.C. title 35, sec. 63) Whenever a patent on application is refused by the Board of Appeals or whenever an applicant is dissatisfied with the decision of the board of interference examiners, the applicant, unless appeal has been taken to the United States Court of Customs and Patent Appeals and such appeal is pending or has been decided, in which case no action may be brought under this section, may have remedy by bill in equity, if filed within six months after such refusal or decision; and the court having cognizance thereof, on notice to adverse parties and other due proceedings had, may adjudge that such applicant is entitled, according to law, to receive a patent for his invention, as specified in his claim or for any part thereof, as the facts in the case may appear. And such adjudication, if it be in favor of the right of the applicant, shall authorize the commissioner to issue such patent on the applicant filing in the Patent Office a copy of the adjudication and otherwise complying with the requirements of law. In all cases where there is no opposing party a copy of the bill shall be served on the commissioner; and all the expenses of the proceedings shall be paid by the applicant, whether the final decision is in his favor or not. In all suits brought hereunder where there are adverse parties the record in the Patent Office shall

> be admitted in whole or in part, on motion of either party, subject to such terms and conditions as to costs, expenses, and the further cross-examination of the witnesses as the court may impose, without prejudice, however, to the right of the parties to take further testimony. The testimony and exhibits, or parts thereof, of the record in the Patent Office when admitted shall have the same force and effect as if originally taken and produced in the suit."

STATEMENT OF POINTS

The Appellant has assigned certain errors and a Statement of Points thereof (Joint App. pp. 15-16) which may be summarized as follows:

1.

The Trial Court erred in holding there was no invention in combining an electrical logging instrument and a caliper or diameter measuring instrument for well bores.

2.

The Court erred in holding there was no patentable significance in the correlating of an electrical logging reading which had been taken simultaneously with a well bore diameter reading.

3.

The Court erred in holding that there was no invention in the omission of cement at a productive area in a well bore after the setting of the casing therein where the information had been obtained by a simultaneous electrical and diameter measuring instrument.

4.

The Court erred in refusing the Appellant's claims 12, 13, 14, 16, 17, and 18 as not defining invention and as being unpatentable over the prior art.

5.

The Court erred in failing to authorize the issuance of a patent to the Appellant under R.S. 4915 covering claims 12, 13, 14, 16, 17 and 18.

6.

The Court erred in concluding that the Appellant is not entitled to a patent containing the claims set forth in this appeal.

7.

The Court erred in authorizing dismissal of the complaint as to all claims with costs against the Appellant.

SUMMARY OF ARGUMENT

The Appellant argues herewith that he is entitled to the six claims which are here on appeal, namely, 12, 13, 14, 16, 17 and 18 (Joint App. pp. 4-7), claims 8, 9, 10, 11 and 19 having been abandoned at the trial before the District Court.

Claim 12, which is representative is paraphrased here as follows:

> *Claim* 12:
>
> The improvement in the art of investigating geological structure penetrated by a well bore which comprises the steps of simultaneously,
>
> (a) measuring at various depths within fluid in the well bore the combined electrical characteristics of the fluid and the surrounding formations, and
>
> (b) measuring the variations in the diameter of the well bore at the various depths, and
>
> (c) correlating the log reading obtained with the variations in diameter to determine the effect on the

log readings of the variations in diameter as ascertained.

The method and instrument for electrically logging a well bore is old in the art where an electrode is lowered into a well bore and another electrode placed in the ground and the log reading is an indication of the resistivity of the formation. Different formations vary in resistivity. In this manner, formations containing oil and gas are detected as to elevation and now adays, practically every well is logged electrically.

It is also old in the art to lower a caliper or diameter measuring instrument into a well bore. Such instruments were devised in order to measure the size of the hole in order to compute the volume of cement required to form a seal around the outside of the pipe or well casing after such casing is positioned in the well. Such a diameter measuring device indicated variations in diameter so that the volume of the bore less the hole filled by the casing could be computed.

The feature which is believed to be new to this applicant is the combination of the electrical logging instrument and the diameter measuring instrument for the purpose of obtaining an entirely new result. Thus for instance, the Appellant has combined the electric logging instrument and the diameter measuring instrument together so that they are lowered on one cable and simultaneous readings are taken at exactly the self-same elevation at the same time. The Court may ask of what value are such simultaneous readings? When the electric logging instrument is lowered into a well on a wire line or cable, it is not uncommon for the cable to stretch from fifteen to twenty feet in length. The operator can only guess at the stretch to interpret the log which he obtains for the purpose of locating the elevation of an indication of a productive formation. When the calipering measuring instrument is run separately and independently of the electric logging instrument also on a wire line or cable, the stretch in such cable may be entirely different than the stretch in the logging cable so that the operator interpreting the diameter readings must also estimate the stretch in his cable.

The Appellant herein, therefore, by combining the two instruments, running them on a single cable at the same time then obtains two simultaneous readings, one, which is the electrical log, the other, which is the diameter reading, *but* he thus knows that the two readings are identically at the same elevation.

The applicant has utilized these two simultaneous readings first to interpret the electric log as it may be in error due to an enlarged portion in the well bore. It is known in the rotary method of drilling the well that the mud pumped down through the drill stem and circulated up through the well bore washes away the softer earth formations around the well bore and enlarges the bore. This enlargement is naturally filled with drilling mud. A larger diameter of drilling mud affects the electric log reading. The Appellant is therefore the first to provide simultaneous readings which assure the interpretator enough information to properly correct his electrical log for variation in the diameter in the well bore.

A second advantage is the knowledge obtained by the interpretator that a porous formation, from which production is sought, has been substantially enlarged. He obtains this information because of the simultaneous diameter and electric log readings. This information can be utilized by the operator of the well to avoid cementing of the enlarged area on the face of the productive formation. It is known that many, many wells have been abandoned as non-productive because it has been impossible to penetrate a large body of cement around the casing which was pumped into the enlarged area of a porous productive formation which had been washed out. The Court is probably aware of the fact that after the well is drilled, the casing is run into position and cement pumped downwardly through the casing and upwardly there around; then the casing is perforated by shooting bullets through the casing at the elevation where a productive formation is supposed to have been ascertained by the electric log. It has been found that such bullets seldom penetrate more than two or two and one-half inches through the casing and the cement therearound. Thus if a porous formation were washed out for six or eight inches and such washed out area filled with cement, the bullets would never penetrate the cement. The well would be abandoned.

The applicant has therefore devised claims such as 13, 16, 17 and 18 here on appeal (Joint App. pp. 5-7) relating to the entire procedure of the simultaneous logging and diameter reading and then the cementing of the casing above and below the productive area so as to avoid placing cement in the washed out enlarged area.

The claims here on appeal represent a very substantial advance in the art and since this appeal has been pending, the Patent Office has issued a patent to another inventor on a later filed application in which claims were allowed for correcting an electrical log reading by a simultaneous diameter reading. This is shown in the patent to Bays 2,392,357 issued January 8, 1946, which incidentally was the exact day of the trial of this appeal before the District Court.

The ground of refusal of the claims on this appeal has been on the sole ground that the claims lack invention. The Appellee has presented prior art patents which show electric logging devices. He has presented prior patents showing diameter measuring devices and he has shown prior patents showing the electric logging devices combined with (a) a gun perforator tool, (b) with a thermometer, (c) two electric logging devices spaced apart in the well bore, *but the Appellee has failed to show the combination of an electric logging device and a diameter measuring device.*

Needless to say, the combination of some other instruments, which are different, accomplish a different result, and do not suggest the applicant's result, must fail in anticipating the Appellant's claimed invention.

ARGUMENT

Appellant's Method Constitutes a Substantial Contribution to the Art

At the trial of this case, the Appellant's Exhibits 1, 2, and 3 were offered in evidence and the Appellee's Exhibits A to N inclusive were received.

The invention relates to a part of the procedure in well drilling by the rotary method whereby very desirable information can be obtained as to the nature and location of the various earth strata which are penetrated by the well bore.

To review briefly the drilling of a well, the drill bit, which may be of any or various types, is connected to the lower end of a piece of pipe. This bit is started into the earth by mechanically gripping the pipe and rotating it. As the bit advances into the earth, additional pieces of pipe are added and many wells are now drilled to 10,000, 12,000, and 15,000 feet.

Naturally as the well becomes deeper, more and more power is required to turn the string of pipe in the well bore that has already been drilled and as a result it is not uncommon to use pipe that is six inches in diameter, has a very thick, heavy wall, and may weigh as much as thirty pounds to the foot. Thus, if a well were being drilled at 10,000 feet, just the weight of the pipe alone could readily be as much as 300,000 pounds or 150 tons. A six inch pipe two miles long is of course quite flexible. If it were laid out on the ground, it could be brought around into a complete circle without deforming any of the thirty foot lengths of pipe which are thus coupled together. So too, in the drilling of a well. It would be absolutely foolhardy to attempt to let the weight of this pipe rest upon a bit because the pipe is almost like a piece of string, and is as a matter of fact called a string of drill pipe. The usual practice is to allow only 20,000 or 30,000 pounds of weight to rest upon the bit to cause it to advance into the earth. The other 270,000 or 280,000 pounds, weight of the pipe, is suspended from the crown block in the top of the well derrick.

As the bit advances, the earth formation which is loosened by rotation of the bit must be carried away and tremendous pumps are provided to pump what is known as drilling fluid or drilling mud down through the drill pipe so that it discharges at the bit. This flow of liquid carries away the cuttings and the liquid flows upwardly in the well bore outside of the pipe to the surface where it discharges into a pit so that the sand and other cuttings may settle out by gravity and the liquid is then picked up by the pumps and again circulated into the well bore down through the drill stem.. The practice has developed of using various ingredients in this liquid, first to make it heavy so that the weight of the liquid in the well bore will be greater than the weight of the earth at the side of the well bore so that caving of the earth is in this manner forestalled. Other materials which vary the chemical composition, the amount of solid matter in the liquid, and other characteristics are accurately controlled, usually by providing a chemical engineer on the drilling rig known as the mud man.

It is not uncommon to circulate 400 or 500 gallons of mud per minute down into and up through the well bore. It is not uncommon for the pumps which circulate this liquid to maintain pressures 500, 1000, or 1,500 pounds per square inch in the mud to cause it to return to the surface.

As the drilling mud moves upwardly in the well bore outside of the pipe, it will be remembered that this pipe is being turned or rotated anywhere from fifty to one hundred revolutions per minute so as to turn the bit. As a matter of fact, the pipe flops around in the well bore to a considerable extent. In some instances, if the driller allows too much weight to rest upon the bit, the pipe may buckle and thrash out a cavity of several feet in diameter in a soft sand or other formation which has been passed through. On the other hand, the liquid which is moving up through the well bore washes against the wall of the well bore and very often washes away considerable of the earth formation, especially in the softer sandy formations, so as a matter of fact the well bore may be substantially enlarged in many places. An average size of drill bit is eight and three-fourths inches so that the original hole drilled would be this diameter, but very often the softer formations wash out to twelve, fourteen, or sixteen inches in diameter, thus forming enlargements along the well bore.

It is well understood that most all oil and gas deposits occur in the more or less porous sandy or limestone formations, that in a majority of instances, the oil and gas is floating on top of salt water. The salt water tends to force the oil through the porous sands. It is thus evident that very often the most valuable formations are those which are washing away around the edge of the well bore.

A number of years ago a procedure was invented and covered by many patents, wherein an electrode connected to an electric circuit would be lowered down into the well bore on an electric cable. Another electrode would be inserted into the earth at the surface of the ground. When the electrode in the well was charged with electricity, the mud or liquid in the well bore and the earth formations between the electrode at the surface and the electrode in the well st up a certain resistance to the flow of electricity between the two electrodes. There are many variations of the procedure of course, but the principal idea being to determine by the amount of voltage and current applied to the electrical circuit as a measure of the resistivity of the earth. Various earth formations vary in resistivity. After years of experimentation and commercial development, it has been possible to make a log or a graph which is formed on a continuous recording machine while the electrode is lowered down into or withdrawn from the well bore. This log measures the variations in resistivity. The variations are quite sharp in many instances as the electrode passes different formations and by experience the interpreters have been able to look at the logs and designate the variations in resistivity as indications of the type of formation which caused the resistivity variations. These variations are known in the Industry as "kicks" or "excursions" when they are viewed on the log. Figs 1B and 1C in the Ennis patent 2,228,623, (Joint app. pp. 154) shows such logs.

It is obvious that the liquid in the well bore must act as a conductor as well as the earth formations which surround the well bore. This science of electrical well logging has developed commercially to the stage wherein it has been found that variations in the diameter of the well bore as a matter of fact cause variations in the resistivity. This is principally attributable to the fact that the large diameter well bore contains a large diameter column of the drilling mud. For instance, the patent to Huber 2,072,950, (Joint app. pp. 130) relied upon by the Defendant in this case points out on page 4, Column 1, lines 22 to 40, the following:

> "For example, if the sensitivity is adjusted to give good detail in a bore hole 6 inches in diameter, the same sensitivity adjustment when measurements are being made in a 12 inch hole would give little or no detail and the total throw of the galvanometer would be so small that the breaks in the curve would be more or less masked and the location of the discontinuities in the strata would not be indicated definitely. In other instances the salinity of the fluid in the bore hole might be such as to give too great a throw to the galvanometer needle, causing most of the curve to fall outside the limits of the recording strip or film. In practice, the sensitivity is adjusted by adjusting the resistor 27 immediately after the electrodes are lowered below the cased portion of the hole, at which level the bridge is adjusted as previously described."

It is thus apparent that Huber pointed out that it was necessary to consider the effect on his recordings of the difference between a bore hole drilled six inches in diameter and a bore hole drilled twelve inches in diameter, so Huber opints out how he has to adjust his equipment for the difference in diameter. Huber is of course talking about using his equipment in one instance when he has drilled a six inch hole and then makes adjustments in it when he runs it in a well bore which has been drilled twelve inches in diameter.

Huber, however, makes no mention of the phenomenon of a washed out formation, where Huber might believe he had a six inch hole or well bore, as that was what was drilled, when as a matter of fact if the hole was washed out to say twelve inches, Huber had no way of knowing that such a washout had occurred.

Huber points out in the paragraph quoted above that he would get little or no detail in his log in a twelve inch hole if it was adjusted for a six inch hole. Thus Huber shows conclusively that if an accurate log, giving valuable information, were made in a six inch well bore which as a matter of fact had washed out to twelve inches in some places, the readings at the twelve inch area would give little or no detail. Consequently, such readings would be of little value.

The applicant *Smith is the first to conceive the idea of simultaneously combining with the electrical well logging equipment a device which would automatically and simultaneously measure the diameter of the well bore.*

The Court will readily appreciate this added information which appellant Smith has been able to obtain by the procedure described in his application here on appeal, namely, that two logs are taken simultaneously. One is the usual and electrical log such as described by Ennis and Huber. The other is known as the caliper log wherein the diameter of the well bore is measured. These two logs are taken simultaneously and may be taken on the same recording strips or on separate strips which are correlated so that the operator knows beyond any question of a doubt that the diameter of the well bore shown by the caliper logging is the same elevation as the electrical log. In this manner, by correction and computation, the electrical log can be adjusted, according to the variation in the diameter of the well bore so as to correct any error caused in the electrical log due to the fact that the well bore varies in diameter and the greater or lesser diameter of drilling mud had been included in the resistivity reading of the electrical log.

The diameter would be shown on the caliper log and the adjustments described by Huber could readily be made FOR THAT LENGTH OF THE LOG WHERE THE CALIPER HAD SHOWN VARIATIONS IN DIAMETER.

One of the teachings of Smith's contribution was this simultaneous recording by arranging the electrical logging equipment and the caliper or diameter measuring instrument at the same elevation and operated by the same cable so that Smith would be assured that the two readings, that is the electrical log reading and the caliper or diameter log reading, were taken simultaneously and both were readings at exactly at the same elevation throughout the logs.

The Court may ask of what value would these simultaneous readings be? The answer is that the operator is assured that his resistivity or electrical log reading has been affected by the discovery of a washed out area or an enlargement in the diameter formed by the calipher in the well bore and he can make a suitable correction so that he is able to observe from his electric log more accurate readings because he knows he has corrected them for variation in the diameter of the well bore and variation in the reading to an excessive amount of drilling mud, the resistivity of which has been measured.

The corrections applied to the electrical log might indicate to the interpreter that he had an oil sand rather than a salt water sand, that he had a producing formation rather than one which was non-producing. Various other indications could be thus corrected and interpreted accurately rather than erroneously.

Let us bear in mind, however, that Smith was not the broad inventor of the caliper or the diameter measuring device for well bores. Such instrument was devised by M. M. Kinley as shown by the two Kinley patents 2,102,080 and 2,267,110 found respectively at Joint Appendix pp. 138 and 165, relied upon by the Defendant. Kinley intended to measure the diameter of the well bore for an entirely different purpose than that for which Smith is measuring diameters of well bores. Kinley desired to know the diameter of the well bore at specific elevations because after the well has been drilled, the heavy drilling mud must of course be removed from the well. The earth formations would cave in and block off the well unless a string of large diameter pipe or casing is lowered into the well bore. Such operation is known as casing the well and this casing is run into the well after the drill bit has been removed while the well is still full of mud and then after the casing is landed in place, the next step is to anchor the casing so as to exclude other liquid from leaking in around the casing. The usual practice for anchoring the casing is to pump cement down through the casing and force it out the lower end of the casing so that it moves up around the outside of the casing and fills the annular space between the wall of the well bore and the outside of the casing or pipe. When this cement sets, the casing is then of course firmly anchored and there can be no leakage around the lower end of the casing into the interior thereof. Now the well is ready to be brought into production and very often the drilling fluid is now replaced with water or sometimes with oil pumped in at the surface. What is known as a perforating gun is now lowered into the casing to the elevation where the electric log has been interpreted as showing an oil or gas sand or a productive earth formation.

This gun discharges bullets readily through the casing so as to cause holes or perforations, often a quarter or one-half inch or even seven-eighths of an inch in size. These bullets are propelled by such an explosive charge that they readily penetrate the steel casing and are supposed to move out through the cement which has solidified around the outside of the casing and the bullets are supposed to penetrate the earth formation, leaving a hole or opening so that oil or gas from the formation moves through the opening into the casing. The oil is then elevated to the surface and in this manner recovered..

As indicated above, the softer sand and porous formations are usually those which wash out during the drilling operation. If a soft formation washed out, then naturally an enlarged cavity around the casing remained and would be filled with cement during the cementing operation. Thus an operator might have a ring of cement six or seven or even eight inches thick around the casing, at a porous washed out formation, when he firmly believed that he only had a half inch or an inch of cement at the most around the casing. Naturally the bullets would not penetrate such a large ring of cement and after the perforating gun was removed, low and behold, the operator recovered no oil solely because the bullets had not penetrated the large ring of cement which the operator knew nothing about.

Kinley devised the caliper device for an entirely different purpose; that of measuring the diameter of the well bore in attempting to locate any enlarged area so that such area could be filled with cement so as to assure the sealing of the casing and to also determine the amount of cement required to fill the enlarged area. The enlarged area could then be filled with cement and the operator assured that the casing was properly sealed in place. In this manner, Kinley sought to *purposely form a large ring of cement around the casing.*

The difficulty with the procedure described heretofore was that the electric log was run at one time before the casing was set in the sell, then the calipher log to measure the diameter was run at another time on a different cable, usually by a different operating concern. The result was that there was no assurance that the kicks or excursions on the electric log shown by one service company were at the same elevation as the variations in the diameter shown by the caliper or diameter log made by another service company. As pointed out by Ennis 2,228,623 supra, (Joint App. p. 154) page 2, column 2, "the cable might stretch many feet" and he gives an illustration of a stretch of twenty-one feet. Thus, how in the world could the interpreter of an electric log *made on one cable* be assured that the kicks or excursions thereof were caused by a variation in diameter shown by a caliper or diameter log when say they were as much as twenty-one feet apart as to elevation. The interpreter would merely be guessing and have no definite information.

The inventor Smith herein as stated above, combined an electric logging device and a caliper or diameter measuring device and redevised them so that they *could be operated upon* the *same cable* at the *same time* and suspended at the *same elevation* in the well bore. In this manner, simultaneous readings were taken, simultaneous logs were recorded, and now the interpreter for the first time has before him *two logs which he absolutely knows were taken at the same elevation* and he can now interpret these logs, *one in view of the other,* making the necessary corrections in the electric log for variations in the diameter of the drilling mud in the light of the simultaneous caliper or diameter log.

Never before in the history of the art had such simultaneous readings been taken.

Another feature of the Smith disclosure is an arrangement whereby due to the simultaneous readings thus obtained, the operator of the well knows conclusively the elevation of a washed out formation and can *avoid pumping cement thereinto.* Smith discloses an arrangement for pumping cement below the washed out formation and then providing an opening in the casing a suitable distance thereabove and then pumping cement out through such opening in the casing so as to isolate the porous or washed out formation and in this manner insure that when the casing is perforated in the first place, the porous or producing formation will not be contaminated with cement and there will be no ring of cement around the casing to stop bullets where the casing is to be perforated. The formation will be isolated against intrusion by water or gas from above or from salt water from below due to the provision of the cement seals thereabout and therebelow. The simultaneous logs have given the accurate information so that the casing can be perforated at the porous formation and a well assured. Some of Smith's claims recite this detailed procedure.

It is apparent therefore that Smith has conceived a method and combination of apparatus not heretofore known or used. This contribution eliminated *first* running the electric log and then thereafter running the caliper or diameter measuring log and combined the two operations and tools together. It eliminated any *error* which was bound to occur by obtaining two separate logs. It assured the interpreter that his information was correct. It permitted determination that any enlargement in the well bore was at the *same elevation as any pertinent excursion or kick on the electric log.* It permitted completion and cementing of the well in a successful manner where previous practices had resulted in error.

Prior Practices as Exemplified by the Prior Art

The Appellee Ooms has refused the claims of the Appellant Smith which are here on appeal as lacking invention and as being disclosed by the prior art patents, Appellee's Exhibits B to I inclusive (Joint app. pp. -).

The Appellee does not contend and has not argued that the prior art patents suggest the combination of the claims. The ground of refusal is that *no invention was involved* in conceiving the combination of the claims in view of the prior art patents. Under circumstances such as this, the burden rests upon the Appellee to show conclusively that there is some suggestion of the inventive conception in some one of the prior art patents.

The witness Fenning for the Appellant testified at the trial that none of the prior patents even remotely suggested the combination of Smith's claims. On cross examination, r.p. 38, 39, and 40, there were no questions asked of the witness Fenning intimating that the Appellee had any other interpretation of the prior patents than that contended for by the Appellant's witness.

If the Court will respectfully bear in mind that the claims are for the *method of practicing the invention* as distinguished from the apparatus, it is much more readily apparent that the Appellee has provided no suggestion, no anticipation, and that the prior art lacks the combination of the claims.

Taking the prior art patents in order of the Exhibits, the Appellant would like to call attention to the patent to Huber, 2,072,950, (Joint App. p. 130). This patent teaches the idea of taking two electrical logs simultaneously, one close to the circumferential wall of the well bore and one spaced a distance outwardly through the formation or near to the center of the well bore. In this manner Huber is attempting to eliminate the error occurring in the logs due to the presence of the drilling fluid in the well bore.

In Fig. 2, Huber shows that the two logs 29 and 40 and attempts to correlate the two as modifying one by the other due to the presence of the drilling fluid.

This is in a sense one of the things that Smith is attempting to accomplish, but Smith accomplishes it in a better, more economical, more efficient manner by using an electric log and a diameter or caliper log.

Huber does it by using two electric logs, and gives no suggestion of the use of the caliper log whatsoever.

Certainly the Court will readily appreciate that the taking of two electric logs does not suggest the combination of mechanically measuring the diameter of the well bore simultaneously with the taking of an eletcric log. It might be noted in passing, as seen in Figs. 3 and 4 of Huber, that he spaces his electrodes apart a very substantial distance so that as a matter of fact, he does not obtain two simultaneous readings and this is apparent from longitudinal comparison of the two log readings 29 and 40. Huber performs two other operations to some extent simultaneously but they are not the operations which Smith performs and claims, so they do not suggest Smith's inventive concept.

Exhibit C is a patent to Kinley, 2,102,080 (Joint App. p. 138) showing a mechanically operated caliper or diameter measuring device. There is no suggestion in Kinley of simultaneously taking an electrical log where such electrical logging instrument is run *on the same cable as the caliper.* Kinley suggests *no electrical logging whatsoever* and the patents to Huber and Kinley, taken together, illustrate clearly how the examiner is attempting to piece together two separate patents in order to concoct an anticipation of the applicant's inventive concept.

A situation of this sort was passed upon by the Board of Appeals in the Patent Office in a case, entitled:

Ex parte Xenis, et al
59 USPQ 337, 338

> "That each instrument acts independently of other in sense that it can be omitted from combination and other instruments substituted is no reason to hold improper combination or aggregation, especially in process claim."

The next patent relied upon by the Appellee is Bazzoni, 2,167,630, Exhibit D (Joint App. p. 143). The Appellee is using this patent to show that an electric logging device and an instrument for measuring the inclination of a well bore have been run into a well bore together, page

6, column 2, lines 15 to 23 of the patent, making a brief statement that a well surveying device such as shown in the Williston patent 1,960,038, can be attached to the logging instrument. The Williston patent shows what is known as an inclinometer. An inclinometer is used in a well to determine the deviation of the well bore from the vertical. It should be understood that no wells are vertical because they are drilled with the flexible drill stem that turns in a clockwise direction and tends to spin off in a helix. The permitted deviation usually must not exceed three per cent so that the bottom of a 10,000 foot well may be as much as 300 feet off to one side from the top. It is desirable to know the direction of this inclination. The inclinometer has nothing to do with measuring the diameter of the hole. It seems obvious, therefore, that Bazzoni fails utterly to suggest the combination claimed by Smith, namely, a well logging instrument and a diameter measuring instrument coupled together and run into the well on the same cable at the same time, at the same elevation to obtain simultaneous readings.

The principal patent relied upon by the Appellee is the patent to Ennis, Exhibit E, 2,228,623 (Joint App. p. 154). This Ennis patent mentioned hereto points out conclusively the exact problem which confronts the Industry, namely, *determining when* and *where* the *formations have been encountered.* Ennis, however, does not contemplate that the formation may be washed out to provide an enlarged area and therefore gave no consideration to the problem which Appellant is attempting to solve. Ennis is attempting to locate the elevation of a productive formation and discloses a procedure whereby an electric log is run in an open hole while it is filled with drilling mud. This was the usual and well established practice long before Ennis. Ennis then explains how the casing was run into the well and then Ennis runs an electrical logging device and a gun perforating device into the well together on the same cable. The electric logging device makes another log of the earth formations through the well casing and points out, page 3, column 2, lines 7 to 15 of the patent how the presence of the casing has a dampening or dimming effect on the electrical recording circuit. Ennis feels, however, that he will get sufficient information from this second logging operation to enable him to compare it with the first log which he took before the casing was run in an effort to operate his gun perforator at the desired elevation. In other words, the second logging device, which is coupled with the perforator, is merely a double check. Ennis does not say one single word about the variations in the diameter of the hole but he does spend considerable time explaining how the *variations in the length of the cable give inaccurate information.* In one form of the procedure, Ennis discharges radioactive material at a desired elevation so that he can come back again and by detecting the presence of such radioactive material ascertain that he is at a desired elevation. This Ennis patent gives no suggestion of the simultaneous operation of the electrical logging instrument and the diameter measuring instrument lowered into the well bore on the same cable at the same time at the same elevation to obtain simultaneous readings. Neither does Ennis suggest the combination of electric logging, diameter measuring, cementing of the casing at spaced elevations, and the perforating of the casing between the cemented elevations. Ennis, therefore, fails utterly to suggest any of the claimed combinations which are here on appeal.

The next patent relied upon by the Defendant is Kinley, 2,267,110, Exhibit F (Joint App. p. 165). This is a diameter measuring device or caliper which operates by transmitting an electric signal to the surface. Smith has dismissed this appeal as to claims 8, 9, 10, and 11, which are directed to the general type of instrument as shown by Kinley, so that this Kinley patent serves no useful purpose in connection with the claims remaining on appeal. The Board of Appeals allowed the applicant a claim on the construction of the caliper instrument per se as distinguished over this patent to Kinley, Exhibit F. This Kinley patent is not pertinent at this time.

The next patent relied upon by the Appellee is Lee, 2,313,384, Exhibit G (Joint App. p. 170). Lee discloses an arrangement for running an electric logging instrument with a thermometer or temperature recording device connected thereto. It is a well recognized fact that temperature affects the electrical resistivity of various carriers and many electrical recording and indicating instruments render information because of variations in temperature. Lee, therefore, sought to obtain the temperature at the elevation that the recording was being made, so that he could utilize this information in making a temperature correction in his electrical log. This patent is merely illustrative of the fact that the Patent Office has heretofore followed the practice of granting claims for the conception of the use of two instruments simultaneously in a well bore. How the District Court expects to now shut the door and say the present combination lacks invention is inconceivable.

Counsel of course is not arguing that because the Patent Office granted a patent to Lee, that they should now grant one to Smith, because every invention must stand on its own feet and the patent is granted on the merits of the case. But where it has been the practice to grant patents on various combinations of instruments, where the data from the two instruments was utilized to correlate one with the other and make corrections therein, it hardly seems compatible with a consistent practice to rare back and close the door without some good excuse therefor.

Lee fails utterly to suggest the inventive concept of Smith and fails to suggest any combination of structure or procedure for the use thereof which would come within the scope of the Smith claims on appeal.

The next patent relied upon by the Appellee is Ennis 2,317,039,Exhibit H, (Joint App. p. 180). This second Ennis patent discloses an arrangement for introducing an electrolyte which is an electrical conductive liquid. By then running an electric logging device, he is able to determine the flow of the liquid in the well. Ennis is primarily interested in an apparatus for determining water leakage into the well, as indicated by the title of this patent. There is not one iota of information in this Ennis patent which would teach the art anything about the Smith invention as recited in the claims on appeal.

The last reference utilized by the Appellee is a publication of an article relating to a cementing operation. (Joint App. p. 191) As a matter of fact, this publication discloses an operation which shows conclusively the advantages of the Smith disclosures which are here on a appeal.

In this publication, the drilling of a well is described. The diameter of the bore drilled was seven and three-fourths inches while the casing which was run into the hole was six and five-eighths inches in diameter. This left a space of nine-sixteenths of an inch on each side of the casing. There was an annular ring around the casing only nine-sixteenths or just about one-half of an inch in thickness. The publication then describes how 150 sacks of cement would then be pumped down through the casing and upwardly outside of the casing in the well bore in this annular space, which was only nine-sixteenths of an inch wide.

It is a rule of thumb in the Industry that under the general conditions described in this publication, that it can be estimated that a sack of cement will fill an annular space around the casing at least one foot high. Thus in the description by the publication, 150 sacks of cement would have been forced upwardly around the casing a distance of 150 feet. The publication describes the bottom of a well shown as 5,208 feet and points out that there was an oil sand which extended from 5,181 feet down to 5,204 feet. Thus the bottom of this sand was only four feet from the bottom of the hole and the top of the sand was twenty-seven feet above the bottom of the hole. In view of the fact that the cement extended up above 150 feet, is is very evident that the procedure of this publication caused this twenty-three feet of oil sand to be covered or faced with cement over its entire depth, that cement filled the space between the casing and the formation. The publication then describes how the pipe was perforated and oil produced. This seems quite reasonable because of the fact that this sand was only twenty-seven feet from the bottom of the hole and there had been little or no opportunity for the drilling mud moving up through the wall to have washed away the formation because the well had been drilled just barely past this productive formation. The problem described by Smith and the conditions in connection therewith, where cementing of a washed out formation is to be avoided, are entirely absent in the disclosure of this publication. Taking a hypothetical case, however, if this well described in the publication had been drilled on down to 10,000 feet, undoubtedly the sand formation at the 5,200 feet elevation would have been washed out a substantial extent and if then cemented as described in the publication, the cement would have piled up in a wide ring around the casing and the perforating bullets never would have penetrated it.

Smith is not the first to cement the two used spaced elevations. That has been a practice for a number of years and the dual cementer described in the publication, Exhibit I (Joint App. p. 191), is for that purpose but the publication lacks completely the inventive concept of Smith, namely, the running of an electric log and a diameter log at the same time at the same elevation on the same cable to obtain simultaneous readings in combination with the latter cementing below and above the desired location, and the perforating of the location where cementing has been avoided. Certainly the Appellee does not even contend that this publication discloses such a combination.

It is respectfully submitted that none of these prior patents or publications even remotely suggest the combination being claimed.

The Allen patent, 1,946,924, Exhibit A (Joint App. pp. 124), mentioned by the Defendant is not pertinent because it relates solely to the construction of claims such as 8 to 11 as to which the appeal has been dismissed.

The Appellee Has Failed Utterly to Produce Any Suggestion of the Smith Invention

As will be apparent from the foregoing argument, none of the prior patents show the claimed combinations. The Appellee has been content to point out that some of the prior patents disclose the use of two types of instruments of some sort or other together in a well bore. Such generalities do not suggest the inventive idea of Smith.

Smith claims a combination of an electrical logging instrument and a caliper or diameter measuring instrument *coupled together* and *lowered into the well bore on the same cable at the same time at the same elevation and operated at the same time to obtain simultaneous readings,* then the electrical log reading can be corrected in an amount to take care of the variation therein caused by the difference in diameter of the well bore as ascertained by the caliper or diameter log. The Appellee has no suggestion of such a combination.

In order to anticipate an inventive idea, it is the duty and the burden of the Appellee to show somewhere somehow a teaching of the invention. He must produce some prior patent, some publication or some disclosure of the idea. He must produce an anticipation that when read by anyone skilled in the art would teach the inventive idea. In this the Appellee has failed miserably. He does not have any such disclosure. He does not have any suggestion whatsoever in any of the patents or the publications relied upon which suggests Smith's invention. The Appellee has been content to ignore the issue that the prior art fails to suggest invention. He has adopted a general attitude that it is old to run two instruments of a sort into the well bore and that therefore no invention can possibly remain to be claimed by Smith. To Counsel for the Appellant, this is an absurd presumption on the part of the Appellee. First, because if this policy were followed, the Patent Office might as well close up. Second, the Appellee is not consistent in his actions and as an illustration of this, attached to this brief (as pages 312 thereof) is a copy of the Bays patent, 2,392,357, issued on January 8, 1946, the self-same day on which the trial before the District Court was conducted. This patent was granted by the Appellant, admitting thereby that Bays disclosed and claimed an invention. The application on which this Bays patent was granted was filed June 8, 1942; whereas, Smith, the Plaintiff in this case, filed his application on September 20, 1941, or eight and one-half months *before Bays* filed his application.

For purposes of comparison, let's look at this disclosure of Bays for a moment.

In Fig. 1 of Bays, an instrument is shown being lowered into a well bore on a cable 13. This instrument embodies a logging device 11 having a section 19 which is for the purpose of making the primary electric log. Then the instrument carries an intermediate section 20 which Bays says "consists of a well caliper device with arms 21 which bear against the wall of the well 12 as the device is being withdrawn from the well. As is described more fully hereafter, an electric signal proportional to the extension of the caliper arms 21 is transmitted through the cable 13 to the surface."

This arrangement is exactly and identical with the arrangement of Smith. Smith lowers an electric logging device and a caliper device which operates in turn electrically and transmits a signal to the surface. Smith has shown such a combination of structure in his Fig. 1 where the electrical signaling to the surface is in the form of variation of a resistance. Fig. 2 of Smith shows a variable inductance and Fig. 3 of Smith shows a variable capacitance. This voltage of this caliper circuit varies as a functtion in proportion to the diameter of the well bore. This is exactly what Bays does.

Bays has been granted two method claims in his patent involving the method of correcting an electric log reading as a function of the well bore diameter. Fig. 1 of the Bays patent shows a combination tool for electric logging and diameter measuring operated on one cable in a well bore to obtain simultaneous readings. *This is exactly the type of invention upon which claims have been refused to Smith.*

Just what sort of a procedure is the Patent Office following? Is it fair to grant claims to the inventor Bays on an application filed eight months later than the Smith application while refusing claims to Smith directed to the same invention?

The only excuse which the Patent Office can possibly give is if it makes one mistake in granting a patent to Bays, it should not make another mistake and grant a patent to Smith. This is a weak argument and should carry no weight with this Court because the Patent Office has now determined, as shown by the Bays patent, that invention is involved in the simultaneous operation of an electric log and a well caliper or diameter measuring device.

If invention was involved in the disclosure of Bays, so too the self-same invention was disclosed in the patent to Smith. What is sauce for the goose should be sauce for the gander. If Bays is allowed claims, Smith should also be allowed claims. Both Smith and Bays are claiming the invention. If the Examiner handling the Bays application determined that claims to Bays should be allowed for the invention, then he should have withdrawn this appeal and allowed the same claims to Smith and have conducted an interference proceeding to determine which was the first inventor. This should have been done before any patent was granted to Bays. The procedure therefore in the Patent Office has been unfair to Smith and this Court now has an opportunity to instruct the Patent Office to allow Smith the claims which are now on appeal.

In a recent case, the Patent Office Board of Appeals described the procedure to be followed in using prior art patents as references for anticipating an invention:

> *Ex parte Jehle,* 59 USPQ, 437
>
> "Patents are not in the same art as applicant; it is not permissible to use isolated features of one patent as anticipatory when used in machine of other patent where first patent is not concerned with art to which second patent relates and neither of them alone or combined could necessarily be used to accomplish applicant's result; while parts from references may be assembled as stated in claims leaving behind essential elements of patented machines as used by patentees, there is no suggestion in references to rebuild either to make machine stated in applicant's claims."

The Smith Claims on Appeal Are Directed to Patentable Subject Matter

Claims 12 and 14 are the claims of Smith wherein he seeks protection upon the combination of the simultaneous electric logging and diameter logging. Claim 12, when separated into its elements reads as follows:

> *Claim* 12:
>
> The improvement in the art of investigating geological structure penetrated by a well bore which comprises the steps of simultaneously,
>
> (a) measuring at various depth within fluid in the well bore the combined electrical characteristics of the fluid and the surrounding formations, and
>
> (b) measuring the variations in the diameter of the well bore at the various depths, and
>
> (c) correlating the log reading obtained with the variations in diameter to determine the effect on the log readings of the variation in diameter as acertained.

Claim 14 is quite similar to the same general subject matter and reads as follows:

> *Claim* 14:
>
> In the art of formulating an electrical log of an open well bore where the indications obtained are affected by diameter of the column of drilling mud or liquid in the well bore, the step of
>
> (a) obtaining electrical logging readings and
>
> (b) simultaneously therewith obtaining a measurement of the diameter of the bore at the elevation at which the readings are being taken, and
>
> (c) Correcting the reading obtained for variations thereof caused by variations in diameter of the column of liquid logged because of the variations in the diameter of the bore.

It is very evident that the prior patents relied upon by the Appellee do not suggest the method of the applicant because the caption of claim 12 points out the fact that certain steps of the method are to be performed *simultaneously.* These steps are the measuring of the electric characteristics of the fluid in the well and surrounding formations and the step of measuring formations in the diamteer of the well bore and then a step of correlating the log reading in accordance with the variation in the diameter so as to obtain a more accurate log reading. The prior art suggests various other operations but it does not suggest the two which are claimed by Smith. The fact that somebody else invented something else should not be used against Smith as an excuse for refusing claims to which he is entitled. This claim 12 should obviously be allowed to Smith because it is not suggested in the prior art.

The Examiner did have some objections to the form of the Smith claims but was over-ruled by the Board of Appeals and these claims stand before this Court as being properly phrased and framed claims and the sole question for this Court to determine is whether or not these claims recite a new and novel invention.

A fairly recent case passing upon claims of the same general type as those of Smith, where certain operations were performed and observations thereof made, were held to be valid claims by the District Court for the Western District of Pennsylvania, in the case of:

> *Crossley Corp.* v. *The Westinghouse Elec. & Mfg. Co.* 59 USPQ, 466

Claim 14 on appeal is quite similar to claim 12 but the wording is varied somewhat by reciting the electrical logging step and then requiring that simultaneously therewith the diameter of the bore hole should be measured at the same elevation at which the electrical log or reading was taken. The correction would then be made to the electrical log in accordance with the data obtained from the diameter reading. This claim 14 should also be allowed.

Claims 13, 16, 17, and 18 here on appeal are also method claims for the further detailed procedure invented by Smith, utilizing the invention of the simultaneous electric log and caliper log to thereafter proceed with the setting the casing, introducing cement above and below the productive area and then perforating the casing to complete the well. Claims 13 and 17 are representative of this group of claims and may be paraphrased as follows:

Claim 13:

> In the art of obtaining information for the preparing an earth bore for the production of petroleum the steps of,
>
> (a) simultaneously electrically logging and measuring the variations in the diameter of the bore so as to obtain information of the electrical characteristics of the earth formations penetrated by the bore and to correct such information as it may be varied due to variations in the diameter of the bore.
>
> (b) positioning a casing within the bore,
>
> (c) introducing an amount of cement as indicated by the diameters measured which will effect the cementing of the casing above the area and below the area of productive formation as indicated by the log, and
>
> (d) thereafter perforating the casing at said indicated formation.

Claim 17:

> A method of obtaining penetration of the shot into a productive formation in a well bore where the formation is washed out to a larger diameter than the bore during drilling by excluding such area from cementing which comprises
>
> (a) calipering the well bore to ascertain the location, presence, diameter and extent of the washout,
>
> (b) running a casing into the well,
>
> (c) cementing the casing at spaced elevations above and below the washed out area so as to avoid filling the washout with cement which might not be penetrated by the shot,
>
> (d) shooting the casing to form perforations therein at the non-cemented area at the elevation of the washout, and

> (e) simultaneously on the same calipering device supporting an electrical logging mechanism to determine the nature and characteristics of the washed out formation.

The only defense presented by the Patent Office to this group of claims was the arguments that the electric logs are old, caliper measuring is old, cementing is old. These facts are all true, but nowhere has the Patent Office been able to show this Honorable Court any pertinent suggestion or disclosure of how these three procedures would be combined together in a manner in which Smith is utilizing them each combined with the other and dependent theron in order to effect an eventual and successful result. The procedure in situations of this sort is readily shown by the following cases:

Ex parte Smith, 51 USPQ 332,

Patent Office Board of Appeals

> "Prior patents cannot be combined to meet applicant's claims since they teach opposite from applicant and operations of devices disclosed in patents appear to be antagonistic, there being no teaching how they could be combined so as to obtain conditions called for in claims."

It is also well established that prior art should carry some suggestion of the inventive idea so that it would teach the invention to such an extent that there would be no invention left for the applicant against whom the prior patents are being used. It is not enough to merely anticipate one feature in one patent, another feature in some other patent and still a third feature in a third patent because in attempting to concoct a rejection of this sort, the Patent Office is not following what is taught in the prior art but is following what is taught by the applicant and then attempting to piece together an anticipation with the knowledge of what the inventor has already done. It is of course easy under circumstances of this sort to say that no invention is involved, that no difficult problem has been solved, and that it was easy to do what the inventor has done. Situations of this sort have been treated on many occasions by the Patent Office and the Courts as well. For instance, a case directly in point is the case of

In re Deakins, 96 Fed. (2d) 845, CCPA, 496 O.G. 569

> "We have carefully examined the references for a suggestion of appellant's combination and the new and useful results obtained thereby, but have found none. Of course, if the references are examined in the light of appellant's disclosure, the solution of the problem confronting appellant seems simple. A problem solved is no longer a problem, and one is prone to overlook the fact that it ever existed. Whether the solution of a problem involves invention, is a matter of opinion."

Another decision which is in point has been handed down by the Court of Appeals in the case of

Mathieson Alkali Works v. *Coe,* 99 F. (2d) 443-447 CADC

> "In our view, therefore, the discovery made by the applicants in the case constituted invention. Their process was not taught by the prior art; in fact, it contradicted the teachings of the prior art, and in so doing produced a new and useful result. It met a long standing need of the industry . . . a practical method of bleaching cellulosic material without deteriorating the material itself; and it constituted a marked advance in the art."

A similar situation to that of Smith and the Patent Office was passed upon in the case of

Lewis Invisible Stitch Machine Co. vs. *Columbia Blindstitch Machine Mfg. Corp.,* 37 USPQ 635, Dist. Ct. S.D. New York,

> "You cannot create an anticipation by building up a mosaic, but that to constitute an anticipation you have to have something that is integral in one patent. That is not found in either of these references."

The Appellee is thus attempting to follow the procedure condemned by the Courts by making up a mosaic by using eight prior patents. Certainly such a procedure is not permissible under the Patent practice.

It is very obvious that none of the prior art patents disclose a procedure such as called for in the Smith claims. Some of the prior patents were attempting to solve the same problem. Some of them solved it in a different way, but none of them solved it in the manner of the method claims of Smith. The following decision is believed to be in point:

> *G. G. Brown, Patent Office Board Board of Appeals,* 25 USPQ 134
>
> Prior art appliances were not intended to operate in same manner as does that of applicant and hence to attempt to read his claims on prior art requires addition of features in construction not shown or suggested by prior art."

The applicant's claims are quite limited as to the steps of his process and it is apparent that the prior art does not suggest the inventive procedure.

One of the arguments of the Appellee is that the applicant's procedure should be obvious in view of the prior patents. This question has been determined by the Court heretofore. For instance, the case of

> *Alemite Mfg. Corp., et al* v. *Rogers Products Co., Inc.* (C.C.A. 3) 42 Fed. (2d) 648
>
> "All attempts to distort and magnify prior nonalogous art patent way of anticipation have been condemned by the courts and they will not anticipate a patent when none have the combination of elements of the patent."

The fact that the prior patents cannot be used to perform the applicant's process was considered carefully before the Board of Appeals in the Patent Office in the following decision:

Ex parte Schaffert (*Pat. O. Bd. of Appeals*) 4 U.S.P.Q. 24

> "Application for patent is not anticipated by prior art which cannot be used in manner of applicant's device but must have portions removed and be substantially altered in order to be so used."

This Court of Appeals passed upon this question in the case of

Hurd vs. Coe, Comr. Pats., 32 U.S.P.Q. 420, 17 FS 312

> "None of the references show combination nor are any of the devices of references intended or adapted to functions as that of applicant; in rejecting application Patent Office has built up hypothetical structure from number of patents; this practice of anticipating claims is not approved by the courts."

The Court of Customs and Patent Appeals passed upon a situation almost identical to that of the present situation when they rendered the decision in the case of

In re John Stewart Harris, C.C.P.A., 25 USPQ 456

> "Combination of references may be cited in order to show that all steps of process are old and that invention was not involved in combining them, but where references cited neither singly nor in combination suggest applicant's process, claims are allowable."

From the foregoing decisions, it is believed apparent that the prior patents relied upon by the Appellee, each showing some other idea than that being claimed by the Appellant, failed utterly to suggest the process being claimed.

As intimated above, no one skilled in the art would ever have thought of taking the patents relied upon by the Appellee and from them conceiving the combination which Smith is claming, unless these prior patents teach the idea and the process being claimed. Obviously they do not constitute an anticipation.

If the prior patents do not teach the invention of the claims, then it would seem that the applicant would be entitled to the allowance of the claims by this Honorable Court.

Smith Has Taught the Art a New Combination

It is well settled in patent practice that small changes often result in contributions and advantages entirely out of proportion of the amount of change which is made. The Third Circuit Court of Appeals passed upon a situation of this sort in the case of

> *General Electric Co. v. DeForest Radio Co.*, C.C.A. 37, U.S.P.Q. 67
>
> "In considering change in degree, the test is not the quantum or minimum of change but the quantum of change in function and result; where great results follow a change, the slightness of the change tends to emphasize and make more remarkable, unexpected and inventive the disproportionate results the slight change effects."

It is often also simple to consider a contribution after it has been made and believe that the same should be obvious. The Court of Customs and Patent Appeals passed upon a situation in the case of

> *In re Tracy* (C.C.P.A.), 13 USPQ 91
>
> "Improvement seems obvious, but the fact that no one has used it or at least developed it in this art is an argument in applicant's favor; it seems inventive and is a new combination producing a new and useful result; claims held allowable."

The Board of Appeals have very often granted claims to inventors where the Examiner was attempting to concoct an anticipation out of a plurality of prior patents, none of which show the disclosed inventive concept of the applicant.

> *Ex parte Olcott,* Pat. 2,254,387, 51 U.S.P.Q. 65
>
> "The examiner does not contend that the claims are anticipated by the reference but he takes the position that the invention is obvious and that it is obvious to add Claussen's float controlled valve mechanism to the Stevens combination in the way stated by the appealed claims. What is obvious is always a matter of conjecture, but it is our view that on this record it would be impossible to sustain a holding of lack of invention."

The Tenth Circuit Court of Appeals passed upon the question of what constitutes invention in the case of

> *Skinner Bros. Belting Co.* v. *Oil Well Improv. Co.,* (U.S.C.C.A., 10 Circuit, Dec. 24, 1931 No. 490) 54 Fed. 2d, 896,898, 12 U.S.P.Q. 61
>
> "No formula has been prescribed which affords a solution of the vexed question: Has Inventive genius been exercised, We know that the simplicity of the device does not belie inventive genius. Hughes Tool Co. 1. Int. Supply Co. (CCA 10) 47 F (2) 490-2, and cases there cited. We know that we should try to eliminate 'hingsight'; we know that the fact that the problem existed, that financial reward awaited a solution, and that no one did think of it, is strong evidence of invention."

The Appellee's argument in the present case is to the effect that no invention would be involved in taking the several ideas from the patents of record and compiling from them the process of the applicant and that such a procedure would lack invention. Certainly there is little merit to such an argument when the disclosures of all eight of the patents are considered because no one of them teaches the Appellant's combination. The Appellee has been taught the claimed combination not by the prior art but by the Appellant.

This Court of Appeals quite recently passed upon the question of anticipation in the case of

> *Poulsen* v. *Coe,* 73 App. D. C. 324, 119 F. 2d, 188; 48 U.S.P.Q. 673
>
> "The Patent Office and the trial court in statutory action to obtain a patent erred in rejecting certain apparatus and process claims of an application for a patent relating to the recording of sound on films used in the making of talking motion pictures on the ground that applicants' improvement was anticipated. 35 U.S.C.A. 63."

This Court in the above case appears to have been influenced in awarding claims to the Appellant therein because he had made a contribution to the art and stated:

> "Certain apparatus and process claims of an application for a patent relating to the recording of sound on films used in the making of talking motion pictures disclosed patentable "invention", where applicants successfully eliminated distortion and background noise for the future of the art."

So too in the present case, Smith has made a substantial contribution to the art which involves an invention not suggested by the prior art and which gives information and practices a process to obtain an entirely new and accurate result not obtainable by anything suggested in the prior art.

This Court, in the case of:

> *Stephens Pump Co. et al,* vs. *Coe,* 67 App. D.C. 191; 91 Fed. 2d, 222, 223; 32 W.S. P.Q. 418

held that a small contribution which resulted in an improvement in the art was considered as sufficient to allow claims because the claims recited a structure which "will work" whereas the devices of the prior art "will not work at all". This is the exact situation in the present appeal.

CONCLUSION

It is respectfully submitted that the Appellee has failed to make out a case of lack of invention. The prior art does not suggest the inventive combination of the claims on appeal. As a matter of fact, the Appellee has belied his own arguments by issuing the patent to Bays while this appeal has been pending. It is therefore respectfully submitted that under the foregoing conditions, that the Appellee should be entitled to the claims here on appeal.

Respectfully submitted,

LESTER B. CLARK
EMMETT LEO SHEEHAN

Counsel for Appellant.

Jan. 8, 1946. G. S. BAYS 2,392,357

WELL LOGGING

Filed June 8, 1942 3 Sheets-Sheet 1

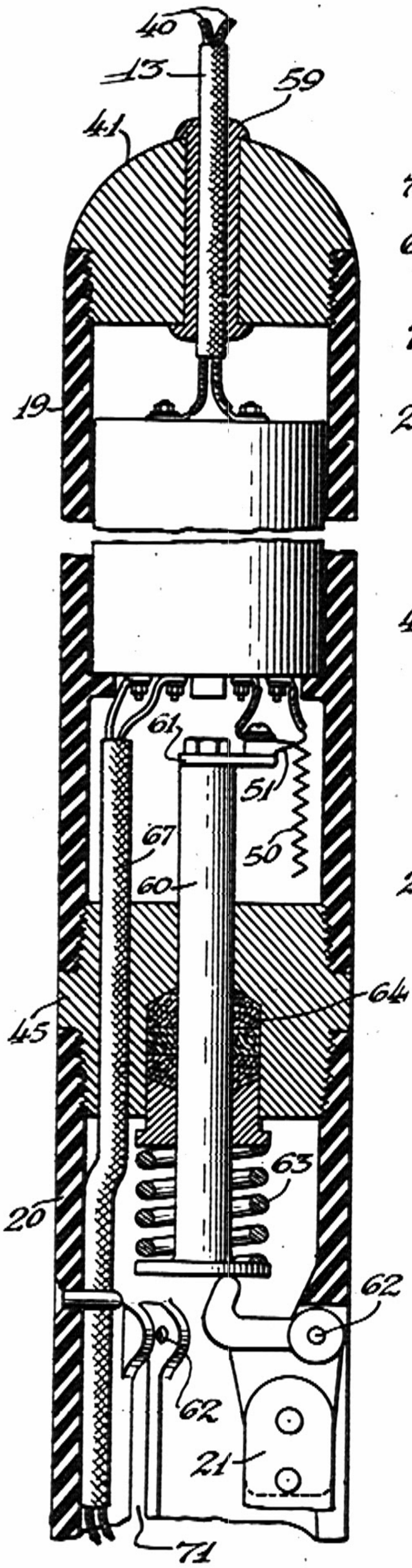
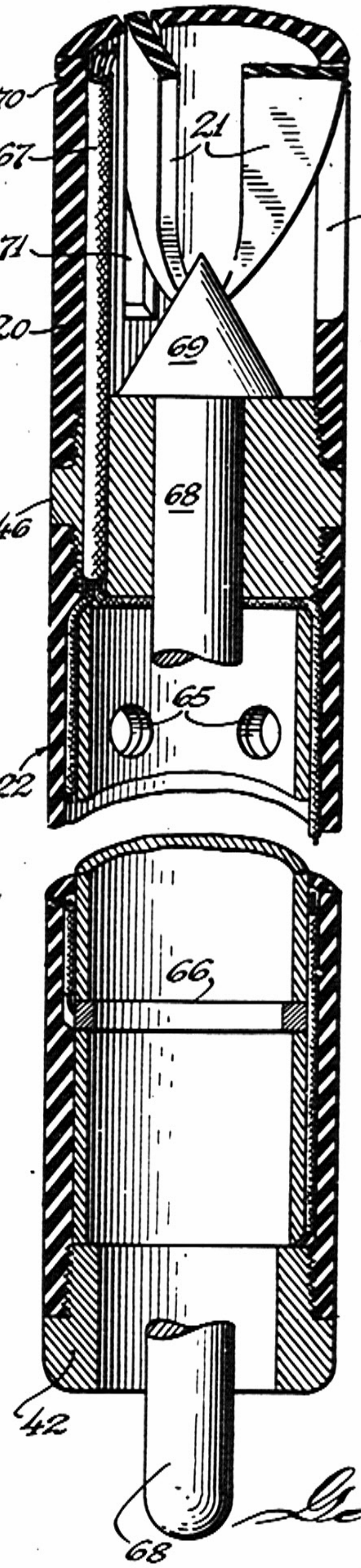


Fig. 5A.

Fig. 5B.



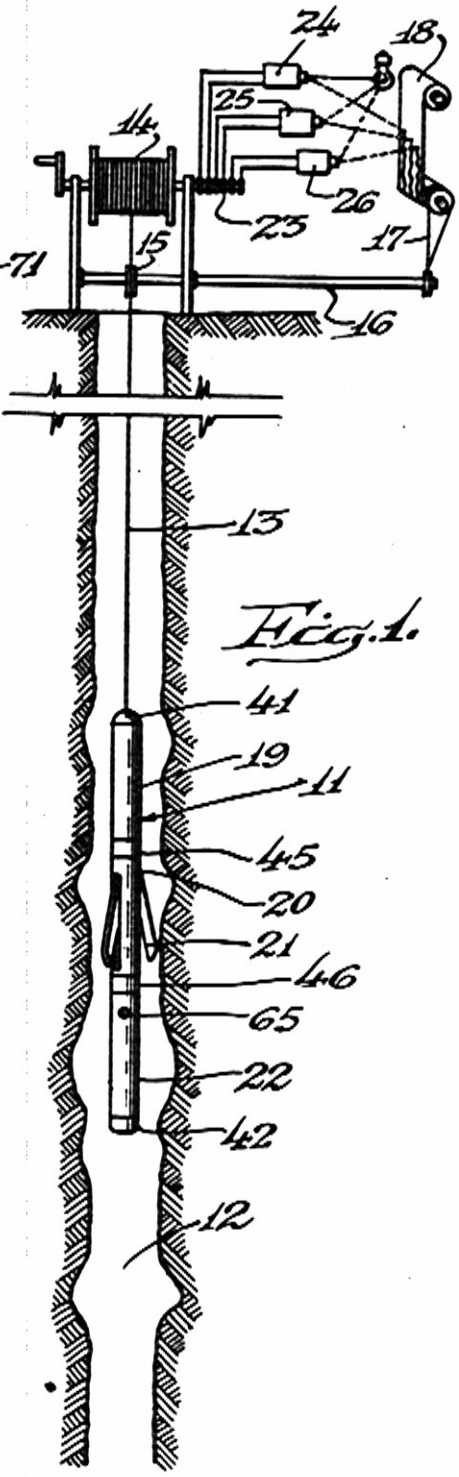


Fig. 1.

Inventor:
George S. Bays
By Paul F Hawley
Patent Agent.

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WELL LOGGING

Filed June 8, 1942 3 Sheets-Sheet 2

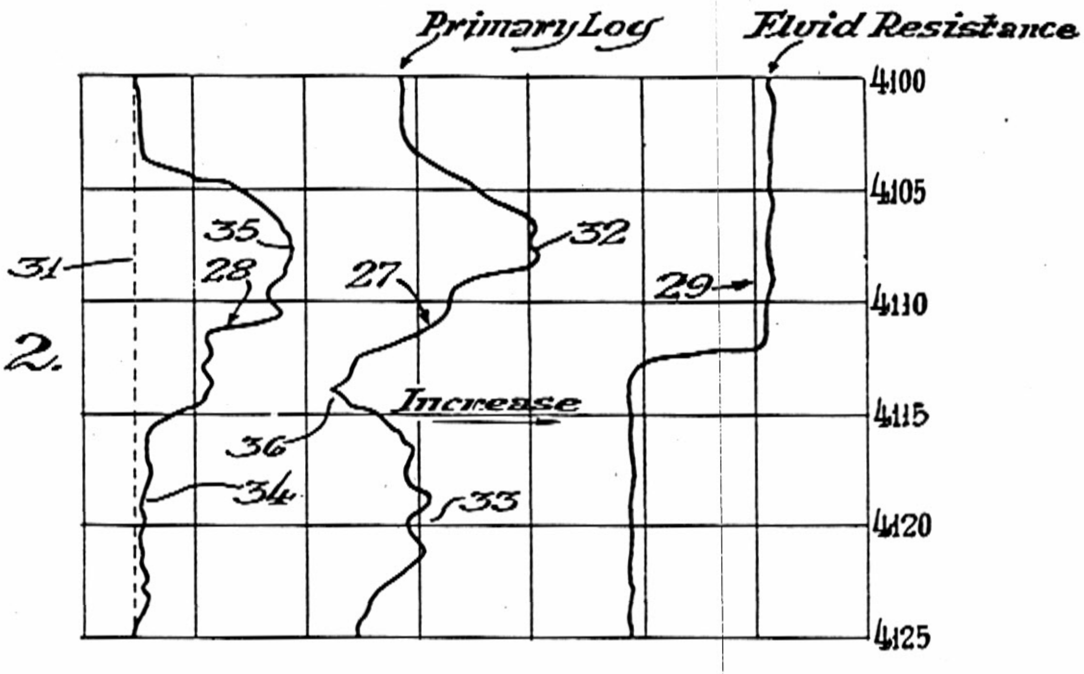

Fig. 2.

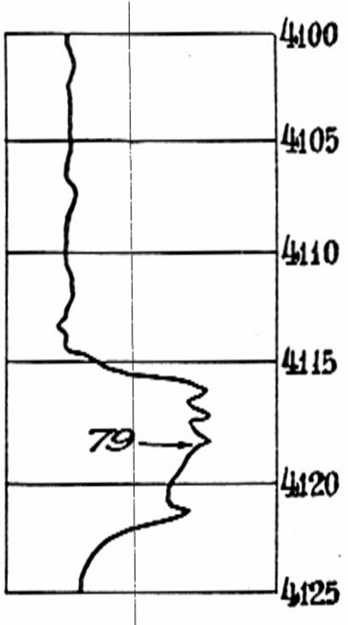

Fig. 7.

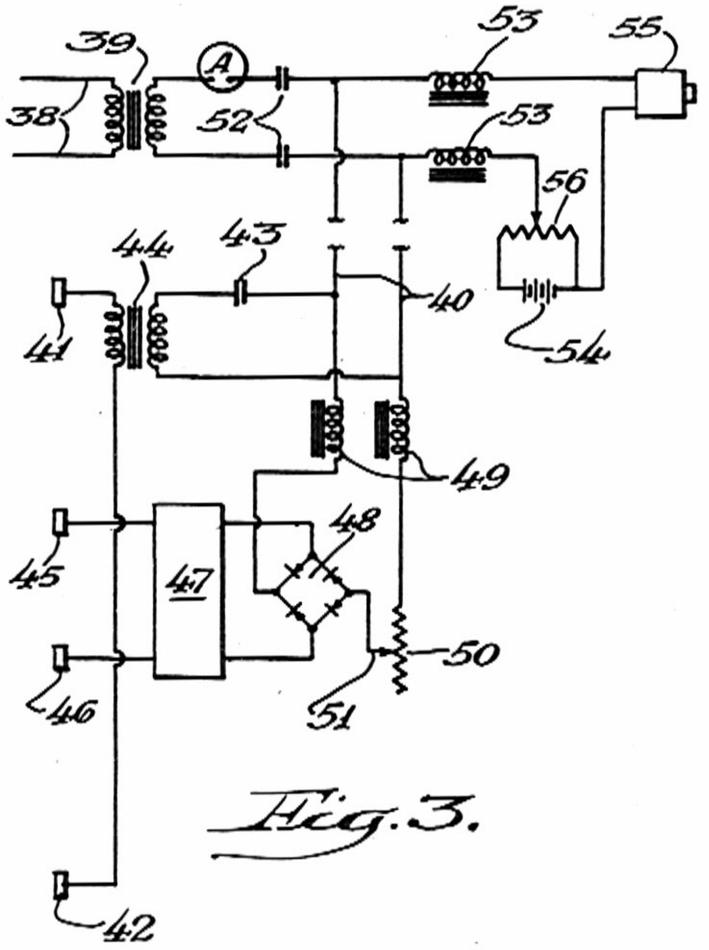

Fig. 3.

Inventor:
George S. Bays
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Patent Agent

Jan. 8, 1946. **G. S. BAYS** **2,392,357**

WELL LOGGING

Filed June 8, 1942 3 Sheets-Sheet 3

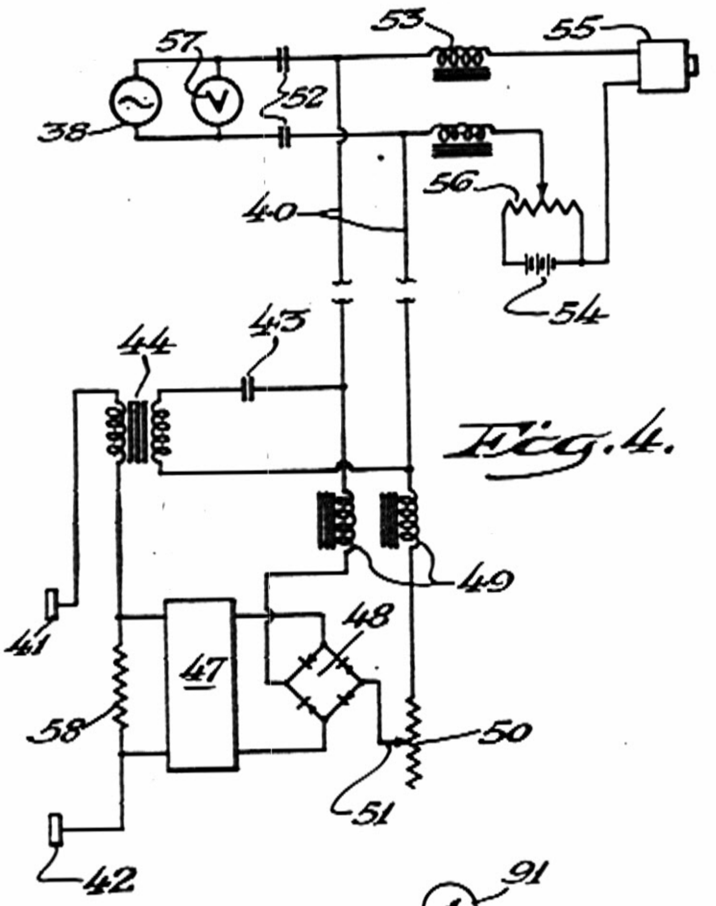

Fig. 4.

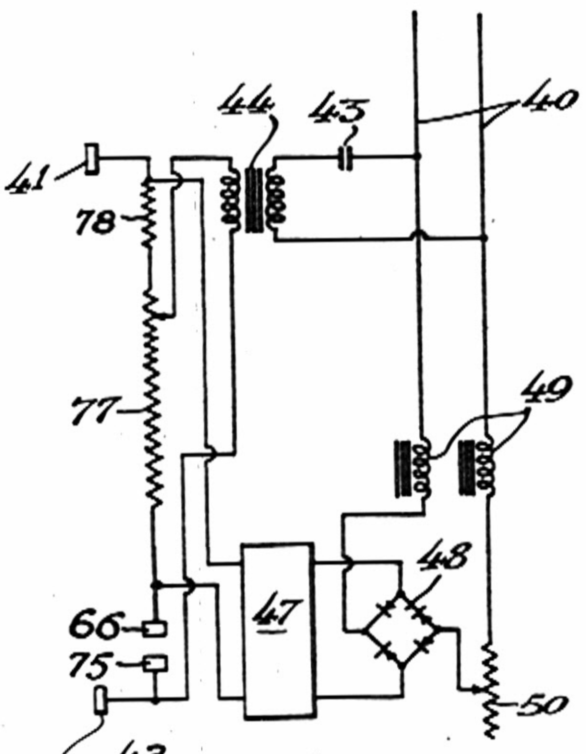

Fig. 6.

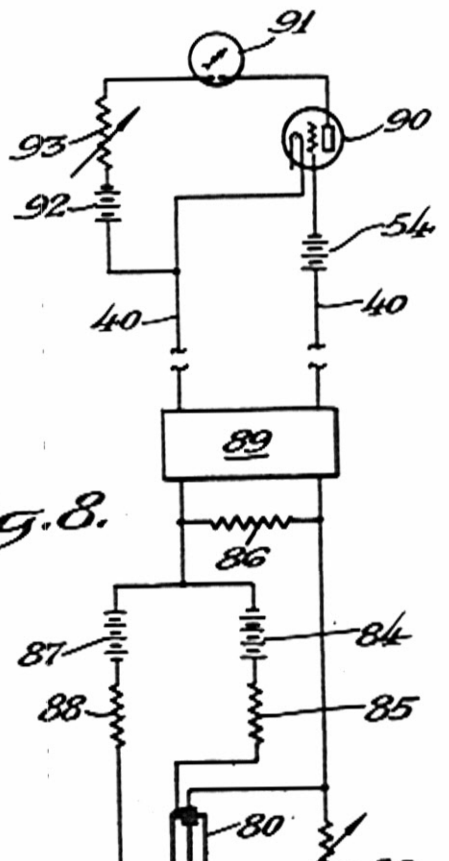

Fig. 8.

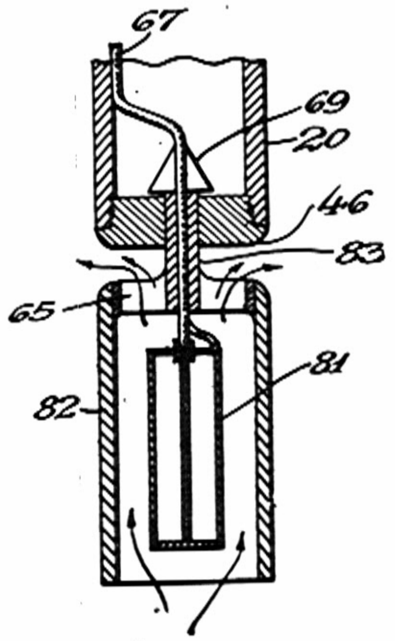

Fig. 9.

Inventor:
George S. Bays
By Paul F Hawley
Patent Agent

Patented Jan. 8, 1946 **2,392,357**

UNITED STATES PATENT OFFICE

2,392,357

WELL LOGGING

George S. Bays, Tulsa, Okla., assignor to
Stanolind Oil and Gas Company, Tulsa, Okla.,
a corporation of Delaware

Application June 8, 1942, Serial No. 446,277

2 Claims. (Cl. 175—182)

This invention pertains to the art of well logging, and more particularly deals with the correction of a primary well log for the character and the volume of the fluid in the bore hole. By the term "primary well log" as used herein is meant the plot of some characteristic of the strata traversed by a well bore as a function of depth without regard to the several variables which may make up the total measured effect. Thus, for example, it will be apparent that the ordinary radioactivity log of a bore hole which simply records total radioactivity regardless of source, variable absorption and other factors is a primary well log.

Various primary methods of well logging, for example natural potential, resistance through an earth circuit, gamma ray, and neutron logging, are now well known and their place has been established in the oil industry. Their use has increased in the oil industry in spite of many unexplainable inconsistencies which are caused by the fact that they are often considerably affected by other factors. It has been suggested that the accuracy of these logs might be affected by the character of the fluid in the hole, as well as by variations in the diameter of the hole, and this invention is directed to making a primary well log simultaneously with a log of the variables which affect it, to remove adequately the recognized deficiencies.

For example, in the ordinary earth circuit resistance log, the following relation exists: the measured or apparent earth circuit resistance R_p is a function of the specific resistivity R_f of the formations, the specific resistivity of the well fluid R_c at the various points involved, and the diameter D of the bore. Both R_c and R_f are in turn functions of the well temperature.

The following table demonstrates the significance of changes in R_c with changes in normality, due to sodium chloride and temperature of the fluid.

Normality	R_c ohms/cm.^{3} at—	
	18° C.	100° C.
0.000		
0.002	4.7340	1.4320
0.010	0.9804	0.02678
0.080	0.1336	0.0415
0.100	0.1008	0.0337

It is quite generally conceded that R_c should be as small as possible for maximum sensitivity in making any earth circuit resistance (R_p) log. As indicated above this log is a function of both R_c and R_f and relative effects of each are dependent somewhat on the relative volumes of each in the circuit through which currents travel in making the log. Since R_c is generally much greater than R_f, the measured resistance R_p increases as the well diameter D increases. Furthermore, regardless of changes in D, R_p decreases as the ratio R_c/R_f increases. Similarly, as the ratio R_c/R_f decreases R_p increases.

From the above it is evident that the effects of the change in fluid resistivity, temperature and bore hole diameter on primary measured earth circuit resistance cannot be neglected. It has been found that an appreciable change in any one of these factors may possibly mask the change in formation resistivity, thus destroying the value of the customary apparent resistance log.

The specific resistivity of oil from an average oil well is many times the specific resistivity of an average brine from the same well. To make an intelligible apparent resistance log of a subterranean formation it is desirable that a fluid of relatively low resistivity be used to condition the well bore before the log is made in order to increase the sensitivity to changes in the formations. In spite of the most exacting precautions, stratification of the fluid will invariably occur while the conditioning pipe is being removed and the logging instrument lowered to the test section.

From the above table, which indicates the effect on the fluid resistance of a change in temperature from well head conditions to bottom hole conditions in a well, it would seem that the effect of temperature change on the primary resistance log could not be neglected. I have found, however, that if a correction is made for temperature, the log gives the primary earth-circuit resistance at a standard temperature, whereas if no correction is made for temperature the log gives the variation in primary earth-circuit resistance at in-place temperatures. The latter is usually preferred, since it is not considered necessary to know the measured earth-circuit resistance of a formation at a standard temperature. On the other hand, when it is desired to compensate a primary log for a temperature anomaly, I have found it convenient to use the method and apparatus disclosed in U. S. 2,330,394 issued on copending patent application 347,570 of Robert W. Stuart combined with the apparatus subsequently herein disclosed.

In comparing logs of a bore hole taken at different times, I have discovered that an accurate reproduction is rarely ever obtained. This is especially true where the logs are of the radioactive properties of the strata. Since the fluid in the well is usually of varying character, it is therefore impractical to attempt to correct a primary log for the effect of the fluid in the bore hole when the primary log and the measurement of fluid character are taken at substantially different times.

It has long been recognized that when a logging instrument is lowered into a deep well there is an appreciable stretch in the cable which cannot be readily ascertained. At least one method has been proposed to evaluate this stretch in which a detectable substance is accurately located at a reference point in the well near the producing formations, so that depths can be computed from the reference point rather than from the surface. Although proposed, this method has not found favor in the art due to obvious difficulties and the expense involved. On deep wells, for instance, it has been found that this stretch of the cable amounts to from 5 to 25 feet depending on a number of variables such as weight of the logging instrument, the fluid velocity, the instrument shape, the fluid density, the nature of the cable, etc. It is almost impossible, therefore, to attain identical conditions when two logging instruments are lowered individually into a well. Although the measuring device may indicate equal depths of two different logging instruments run individually, the variations in actual level could easily amount to as much as 10 or 15 feet, making it impossible to correlate readings from thin strata. Although many of our present important producing formations are found in narrow-veined deposits, there is no doubt but that in the past many of these veins have been overlooked due to the inability to correlate strata.

It is therefore an object of this invention to provide a method of and means for modifying a primary log of the subterranean formations in a well bore, in accordance with a characteristic of the bore hole. This characteristic may be the well diameter, the composition of the well fluid, or other variable associated only with the size of the bore hole and its contents. It is therefore an object to provide a means for automatically correcting a primary well log for changes in bore hole diameter. Another object of this invention is to provide a means for automatically correcting a primary well log for fluctuations due to the character and volume of the fluid in the bore hole at the same time and point that the primary log is made. Another object of this invention is to provide means for correlating primary logs with corrective logs by eliminating inaccuracies arising from elongation of the logging cables. Still another object of this invention is to make a log of the strata traversed by a bore hole, which log is automatically corrected for the amount of and properties of the fluid in the bore hole at each point, thus overcoming inaccuracies arising from the stretch of the logging cable and from transient anomalies of the bore hole diameter and the fluid physical or chemical character.

The foregoing objects together with other objects will be apparent from the following description taken in connection with the accompanying drawings which form a part of this specification and are to be read in conjunction therewith, in which:

Figure 1 is a diagrammatic view of a cross-section of a well and apparatus for simultaneously making a well log and measurements of bore hole characteristics;

Figure 2 is a reproduction of a well log made by the apparatus shown in Figure 1;

Figure 3 is a wiring diagram for a four-electrode, resistance logging system applicable to the apparatus of Figure 1 by the use of which the primary log is corrected for the effect of diameter changes;

Figure 4 is a wiring diagram of a modification of the system shown in Figure 3 for a two-electrode, resistance logging system;

Figures 5A and 5B are vertical cross sections of adjoining parts of a logging device built according to my invention;

Figure 6 is a wiring diagram of electrical apparatus used in connection with the logging device shown in Figures 5A and 5B.

Figure 7 is a reproduction of a log of the section shown in Figure 2 obtained by automatically combining the three variables recorded in Figure 2, through the use of the apparatus shown in Figures 5 and 6;

Figure 8 is a wiring diagram for another embodiment of my invention; and

Figure 9 shows a vertical cross section of part of an apparatus which is a modification of that shown in Figure 5;

Referring now to Figure 1, a combination logging device **11** is lowered into a bore hole **12** on an insulated cable **13**. The cable **13** is wound onto the reel **14** at the surface in a manner well known in this art. The cable **13** passes over a measuring sheave **15** as the logging instrument is moved through the well. This measuring sheave **15** is connected through suitable mechanical connections represented by the shaft **16** and the belt and pulley arrangement **17** to drive the recording medium **18**. Thus the traces or logs on the medium are in direct correlation with the depths at which they are taken. Other methods of correlating the recorder operation with the movement of the exploring device **11** up and down the well bore may be used, as, for example, a Selsyn transmission system, as has been described in the prior art.

In a section **19** within the logging device **11** is placed equipment for obtaining a primary log, such as an ionization chamber or Geiger-Mueller counter together with the necessary electrical appurtenances, for use in gamma ray or neutron logging, or the wiring equipment necessary for earth circuit resistance, natural potential, or other logs. The intermediate section **20** of the logging device consists of a well caliper device, with arms **21** which bear against the walls of the well **12** as the device is being withdrawn from the well. As is described more fully hereafter, an electric signal proportional to the extension of the caliper arms **21** is transmitted through cable **13** to the surface.

Within the lowest section **22** of the logging device are suitable devices for producing an electrical signal proportional to the character of the fluid, used for correcting the primary log for the character of the fluid. As pointed out later in more detail, the fluid in the hole circulates through this section **22** as the device is raised or lowered within the well. The electric output from each of these sections **19**, **20** and **22** is transmitted through conductors of the cable **13** to the surface where the ends of the conductors of cable **13** ar connected to slip rings **23**, from which the electric signals are conducted to the detecting device **24**, **25**, and **26** for recording on the film **18** as primary log 27, caliper log 28 and fluid resistance log 29 respectively, as shown in Figure 2.

As stated above, Figure 2 represents a magnified section of a well log produced by the equipment shown in Figure 1. In the traces an increase in primary earth circuit resistance, diameter, and fluid resistance is represented by the direction of the arrow. This log will now be explained in more detail.

The section from 4100 to 4103 feet is a hard dense material of medium resistivity (evidently dolomite) as indicated by the primary earth circuit resistance log 27, and caliper log 28 which shows that the hole is of approximately the same diameter as the bit, the deflection proportional to the bit diameter being represented by the dotted line 31. The fluid in the hole was of a relatively high resistance as indicated by the conductivity log 29.

In the section 4103 to 4111 feet it will be noted that there is a great increase in the diameter of the hole and a like increase in the primary earth resistance, but no change is noted on the fluid resistance trace. Prior to this invention it might have been interpreted that this increase in resistance as indicated by the peak 32 represented a high impedance formation which was probably a porous section saturated with oil. By comparison with the caliper log, which indicates that the formation in this section has been extensively eroded, and the fluid resistance log which indicates no change in fluid character as compared with the section immediately above, it appears that the change was due to the increase in volume of the high resistivity conditioning fluid, and that this section is probably a shale instead of a producing sand as indicated by the primary earth circuit resistance log considered above. Within the section 4111 to 4115 feet, there is a further change in the formation as indicated by the caliper log 28 and the primary resistivity log 27. This section, although not distinguishable on trace 27 due to a change in the conductivity of the fluid in the well at 4112 feet is believed to be a sandy shale.

Below 4115 feet there is an increase in earth circuit resistance indicated by the minor peak 33, which prior to this invention would not have been considered of any importance. It is known that a sand formation like many other harder strata is not eroded badly by the drilling fluid. The uneroded section 34 of the caliper log, therefore, might indicate a sand formation. Now, by comparing primary trace 27 with those traces of the caliper and fluid resistance, it may be noted that this is a highly resistive sand such as might be expected to contain oil. The peak 33, being less than peak 32 on the primary resistivity log, taken by itself would be held to indicate a low resistivity section of no importance, which might, prior to this invention, have been cemented off. The distinct change in the measured resistance of the fluid at 4112 feet is evidently representative of an interface between the water and oil in the well.

This change in fluid resistivity at 4112 feet accounts for the difference in the heights of peaks 32 and 33 on primary resistivity trace 27, showing that the character of the fluid at the point of interest cannot be neglected. Peak 32 now is easily accounted for by reference to the other two traces which show that the cavity in the shale between 4103 and 4112 feet was filled with a dielectric fluid such as oil.

Below 4122 feet it will be noted that the primary earth circuit resistance trace 27 decreases while neither of the other traces indicates a change. This resistivity decrease suggests that the oil-water interface in the formation is at roughly 4122 feet. This pay formation being so thin might easily have been overlooked had not my invention been used. For instance, had the resistivity and caliper traces been made with individual instruments, the caliper being heavier than the customary electrodes used in an earth resistance survey, would probably have stretched its suspension cable about eight feet more, making the trough 36 on the resistivity log fall opposite the peak 35 on the caliper log. In that case the log of the high resistivity section 4103 to 4112 feet would have fallen opposite the dolomite section above 4103 making it appear that the producing formation was a sand above 4103 feet.

In Figure 3 I have shown a wiring diagram of apparatus for making a four-electrode earth resistance survey and means for correcting this survey for change in well diameter.

A source of alternating current is connected across conductors 38 to a constant-current transformer 39. This alternating current is transmitted through the leads 40 within cable 13 to the logging apparatus in the wall. The equipment which is shown at the lower ends of leads 40 may be conveniently located within section 19 of the logging device 11 as shown in Figure 1. The alternating current is applied to current electrodes 41 and 42 through condenser 43 and transformer 44. Across any intermediate section of the well between electrodes 41 and 42 there is a potential drop that depends upon spacing of the electrodes, fluid volume and character, formation resistivity, etc. The voltage drop across potential electrodes 45 and 46 which preferably are spaced apart of the order of two to five diameters of the hole, may conveniently be proportionately increased in the amplifier 47.

A full-wave rectifier 48 converts the output of amplifier 47 into a direct potential so that it may be transmitted without interference to the surface over the same two leads 40 which were used to transmit power to the logging device. Choke coils 49 isolate the rectifier 48 from the alternating current in leads 40 according to well known usage. The condenser 43 is for a similar purpose in that it prevents the direct potential from being impressed across power electrodes. Variable resistance 50 is included in the direct potential circuit to compensate for changes in well diameter. As is described more fully subsequently, the well caliper arms 21 are mechanically linked to the slider 51 on resistance 50. Thus, increase in the well diameter decreases the value of the resistance 50 in the direct current circuit, so that the recording current is increased, thereby automatically compensating for the decrease in potential drop across electrodes 45 and 46, due to the increase in well diameter.

At the surface condensers 52 and choke coils 53 separate the power and recording potentials. The recording circuit at the surface consists of a battery 54, a detecting device 55 such as an oscillograph galvanometer, and a resistance 56 forming with battery 54 a voltage divider which is used to obtain a zero adjustment of the single trace recording which in this case forms a log of corrected earth circuit resistance, corrected only for volume of the fluid in the hole.

The apparatus shown diagrammatically in the wiring diagram of Figure 3 may suitably be used in the logging device 11 shown in Figure 1. In this case the ends of the instrument 41 and 42 are current electrodes while the potential electrodes 45 and 46 are constructed of conducting sections in the instrument. Intermediate sections 19, 20 and 22 are in this case of non-conducting material, such as Bakelite.

A slight modification of the apparatus of Figure 3 is shown in Figure 4, the main difference being that the apparatus shown in Figure 4 is for use with a two-electrode logging system. In this case a constant potential is applied by alternator 38 through condensers 52 to conductors 40, energizing transformer 44 through condenser 43, so that alternating current is applied across electrodes 41 and 42, which are thereby maintained at a constant potential difference. The magnitude of this drop is proportional to the indication of the voltmeter 57. Changes in the resistivity of the formation are indicated by the changes in the potential drop across resistance 58 which is connected in series with the power supply between electrodes 41 and 42. This potential drop is amplified and rectified as shown in the circuit of Figure 3. The drop across resistance 58 is affected by the volume of fluid in the well between electrodes 41 and 42. Since the volume of the fluid in the hole varies as the square of the diameter and since the motion of slider 51 varies linearly with the diameter, the variable resistance 50 is wound so that the resistance per unit length varies as the square of the distance from the end, in order to compensate directly for change in volume.

A modification of the logging device 11 is shown in Figures 5A and 5B. Conductors 40 in cable 13 pass through electrode 41 into section 19 where I preferably place the electrical equipment associated with the cable and electrodes, as shown in Figure 3 or 4. Section 19 must be separated from the fluid in the hole so a packing gland 59 of any suitable design is used.

As previously stated, the caliper arms (which may be made of any non-conducting material such as wood or moulded plastic), occupy the central section 20 of the logging device. Since slider 51 is connected to but insulated from shaft 60 by an insulator 61, the movement of the caliper arms is registered by a change in resistance 50. Caliper arms 21 are rotatably mounted on the non-conducting wall of section 20 and rotate about pins 62. Variations in the diameter of the hole are transmitted through arms 21 to the shaft 60, which moves longitudinally of the instrument with a change in diameter. It will be apparent that any number of caliper arms may conveniently be used, but I prefer three arms as shown. Spring 63 tends to force the caliper arms 21 against the walls of the hole and in turn centers the logging device 11 in the hole. The spring also compresses a packing gland indicated generally at 64 which prevents contamination of section 19 by the fluid in the hole. Section divider 45 between sections 19 and 20 when used on a four-electrode system forms a potential electrode and hence can be of any conducting material, but, as explained later, when a two electrode system is used, the section dividers such as 45 are preferably of a non-conducting material.

A device suitable for correcting a primary log for the character of the fluid, such as a pair of electrodes, an ionization chamber, a Geiger-Mueller counter, etc., may be placed within section 22. It will be noted that lower electrode 42 is cylindrical to permit flow of fluid through this section as it traverses the bore hole. At the upper end of the section, holes 65 are provided through which the circulation is completed. In the particular device illustrated, a fluid conductivity cell is shown which is composed of electrodes 66 and 42. Two electric conductors within cable 67 connect the apparatus in section 19 with electrodes 66 and 42 as shown in Figures 5A and 5B. The drop of potential across electrodes 42 and 66 is a direct function of the fluid resistivity at the point of measurement. This voltage is used to correct the primary logging indication as explained below.

Before operations start, caliper arms 21 are preferably tied in collapsed position by string or fine wire 70. Then the logging device is lowered to the bottom of the hole. The instrument may be energized as it is lowered through the well to give a primary log of formation corrected only for fluid character. The change in diameter will obviously not be incorporated in this log since the caliper arms 21 are restrained by string 70, keeping resistance 50 constant. When shaft 68 strikes the bottom it raises cone 69, which in turn spreads caliper arms 21, breaking string 70 holding the arms together. A slot 71 in the insulated section 20 is provided for movement of each caliper arm when it is released.

A preferred wiring diagram for this embodiment of the invention where the primary log is of the earth circuit resistance is shown in Figure 6. This circuit is in effect a bridge which is energized from the surface as in Figure 4 by a constant alternating potential through conductors 40, condenser 43 and transformer 44. This circuit, in effect, corrects the primary earth circuit resistance for the effect of varying fluid character as well as the volume of the fluid in the hole. Electrodes 41 and 42 are resistivity electrodes used in the manner described in connection with Figure 4, while the pair of electrodes 66 and 75 constitutes the conductivity cell in which the character of the fluid is determined. Resistivity electrode 42 and conductivity electrode 75 may be combined into one and the same electrode, since they are at the same potential. See, for example, Figure 5B. Balancing resistance 77 in the bridge should be substantially higher than resistance 78 due to the difference in effective total resistance between the resistivity electrodes on the one hand and the conductivity electrodes on the other. Since the conductivity of the earth is generally of the order of 0.1–10 ohmmeters and the conductivity of common drilling fluids is of the order of 2000–5000 ohmmeters, and since the spacing between electrodes 41 and 42 may be from 10 to 100 times as great as the spacing between conductivity electrodes 66 and 75, the ratio of resistance 77 to resistance 78 may be, for example, 100. Thus, for example, resistance 77 may be of the value of 1000 ohms while resistance 78 may be of the value of 10 ohms.

The unbalance of this bridge network which is representative of the difference between primary measured earth circuit resistance and measured fluid resistance, may be amplified by amplifier 47 and then rectified as shown in the circuits of Figures 3 and 4. The direct potential output of the full-wave rectifier 48, is then corrected for change in fluid volume in the section of the well being logged by movement of slider 51 on tapered resistance 50, and the resultant signal is transmitted to the surface over conductors 40. This signal is manifestly proportional to the total primary earth circuit resistance corrected for the effect of variation in fluid character, and for the resistance change due to well diameter variation.

The same section logged in Figure 2 yields a log such as is shown in Figure 7 when the primary log is automatically combined with its corrections. In this case the peak 79 through the section 4115 to 4122 feet points out clearly the oil producing section. It is apparent from the comparison of the primary trace 27 shown in Figure 2 and the corrected trace of Figure 7 that the ease and correctness of interpretation of the corrected log is markedly increased.

As mentioned previously, this invention is not limited to correcting a log of the electrical character of the formation as represented by a resistance or natural potential log, but may be applied equally to gamma ray or neutron logging.

Figure 8 represents a wiring diagram of a modification of the instrument shown in Figure 1 for making a corrected gamma ray well log. In this case all radioactivity, both from the formation and from the fluid in the hole, is detected by the ionization chamber 80, which is preferably suspended between the caliper arms of central section 20. As in the other embodiments, the auxiliary amplifying and other equipment is placed in the upper section 19, but in this instance, the lower section 22 is replaced by the apparatus shown in Figure 9, in which a second ionization chamber 81 is suspended within a cylindrical shield 82 from the chamber 20. This shield 82, which may be of any dense material such as lead, allows only radiation from the fluid to reach ionization chamber 81. A representative sample of the fluid adjacent the primary ionization chamber 80 at any point in the bore hole simultaneously surrounds the correction chamber 81 since the fluid is allowed to circulate through this section past the ionization chamber 81 and out the perforations 65 as the logging device is lowered through the hole. The output from this shielded chamber 81 indicates only radiations from the mud since radiations from the formation are absorbed by the shield 82.

In Figure 8 the battery 84 supplies current to the primary ionization chamber 80, through resistance 85 and common resistance 86. Battery 87 supplies current in an opposite direction through common resistance 86 to the compensating ionization chamber 81, resistance 88, and variable resistance 50, which is varied as previously explained, by change in diameter of the well bore. It is apparent that currents from the two ionization chambers are in opposition through common resistance 86, so that the resultant potential across this resistance is proportional to the difference in the outputs of the two ionization chambers, hence is indicative of the absolute radioactivity of the formation. The total measured radioactivity indication is corrected for the radioactivity due to the character and volume of the fluid. The potential across common resistance 86 is applied to the input of amplifier 89, the output of which is transmitted to the surface through conductors 40, amplified farther, if desired, as by a triode tube 90, and indicated or recorded by a galvanometer 91. A battery 92 supplies current for the recording and amplifying circuit at the surface. It is usually desirable to incorporate a variable resistance 93 in this circuit for volume control, as is well known in the art.

In order that the caliper arms may be released when the instrument reaches the bottom of the hole, the shaft 68 as seen in Figure 5B is replaced with a suitable perforated head 83 in the lead shield 82. In this case when the logging device strikes bottom, cone 69, as in Figure 5B, strikes the ends of caliper arms 21, breaking their binder and releasing them, so that the well may be calipered as the logging device is raised through the well.

While I have described a primary log corrected for certain variables, it is to be understood that I propose to correct a primary log of any variable which can be measured in an oil or gas well for changes in any bore hole characteristic. It is clearly to be understood that by bore hole characteristic I refer only to the physical dimensions of the bore hole and the physical or chemical properties of the fluid within the bore hole as measured in the section of the well being logged, as distinguished from any characteristic associated with or due to the properties of the surrounding formations or the fluids contained in those formations.

I claim:

1. A method of logging the strata traversed by a bore hole filled with fluid which consists in producing a voltage proportional to the apparent electrical specific resistivity of said strata at different depths in said bore hole, simultaneously producing a second voltage proportional to the resistivity of said fluid at said depths in said bore hole, modifying said second voltage in inverse relationship to the bore hole diameter at the same depths in said bore hole, and producing an indication proportional to the difference in said voltages.

2. A method of logging the strata traversed by a drill hole filled with fluid comprising passing an electrical current between two spaced points in said hole, producing a first voltage proportional to the impedance to flow of said electrical current, producing a second voltage proportional to the impedance of said fluid only, applying the difference in said voltages to a variable impedance, varying the value of said impedance inversely in relationship to the diameter of said bore hole and producing an indication proportional to the current through said impedance, whereby a specific resistivity log of said strata can be made.

GEORGE S. BAYS.

BRIEF FOR APPELLEE

In the United States Court of Appeals for the District of Columbia

APPEAL NO. 9399

ALONZO L. SMITH, APPELLANT

v.

CASPER W. OOMS, COMMISSIONER OF PATENTS, APPELLEE

APPEAL FROM THE JUDGMENT OF THE DISTRICT COURT OF THE UNITED STATES FOR THE DISTRICT OF COLUMBIA

W. W. COCHRAN,
Solicitor, United States Patent Office,
Washington 25, D. C.,
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Washington 25, D. C.

United States Court of Appeals
for the District of Columbia
FILED JAN 15 1947
Joseph W. Stewart
CLERK

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727070—47

In the United States Court of Appeals for the District of Columbia

APPEAL NO. 9399

ALONZO L. SMITH, APPELLANT

v.

CASPER W. OOMS, COMMISSIONER OF PATENTS, APPELLEE

APPEAL FROM THE JUDGMENT OF THE DISTRICT COURT OF THE UNITED STATES FOR THE DISTRICT OF COLUMBIA

BRIEF FOR THE COMMISSIONER OF PATENTS

COUNTERSTATEMENT OF THE CASE

This is an appeal from the final decree (Joint App. 14) of the District Court of the United States for the District of Columbia dismissing the complaint in an action brought by appellant, Alonzo L. Smith, under Section 4915 R. S. (U. S. C., title 35, sec. 63) to authorize the Commissioner of Patents to issue a patent to appellant including certain claims of his application Serial No. 411,761 for well surveying device and method. The only issue to be decided is whether the District Court was right in dismissing the complaint on the ground that appellant's claims 12, 13, 14, 16, 17, and 18 (Joint App. 4 to 6) define no invention over the prior art, as represented by appellee's exhibits A to I, inclusive. (Joint App. 124-191).

APPELLANT'S APPLICATION

Appellant's application here involved (Joint App. 33 et seq.) relates to a well surveying device and method and discloses a device used in carrying out a process of simultaneously measuring at various depths within fluid in the well bore the combined electrical characteristics of the fluid and the surrounding formations, that is, electrically logging the well bore, and measuring the variations in the diameter of the well bore at the various depths, and correlating the log reading obtained with the variations in diameter to determine the effect on the log readings of the variations in diameter as ascertained. From this logging procedure information is obtained as to a productive area in the well, and after positioning a casing in the bore, cement may be introduced between the casing and the bore, above and below the area of a productive formation as indicated by the log. Thereafter the casing is perforated at the indicated formation.

THE PRIOR ART REFERENCES

Each of the patents to Bazzoni et al. 2,167,630 (Joint App./43), Ennis 2,228,623 (Joint App./54), Ennis 2,317,039 (Joint App./60), and Lee 2,313,384 (Joint App./70) teaches that different values commonly investigated in a well bore may be investigated simultaneously and in the same location in a well bore, by means of a single cable, with indicating apparatus located in an electrode carrier within the well, or at the earth's surface.

Patents to Kinley 2,102,080 (Joint App./38) and Kinley et al. 2,267,110 (Joint App./65) illustrate known methods and means for securing logs of well diameter, from which the well contour may be determined and suitable information gained.

The patent to Huber 2,072,950 (Joint App. 130) teaches a method of making simultaneous electrical tests, discusses incidentally the known effect of variations in the diameter of the bore hole, and makes an adjustment to compensate for difference in diameter.

The patent to Ennis 2,228,623 (Joint App. 154) also discloses running an electric log in an open hole, cementing in a casing and thereafter perforating the casing with a gun.

The publication "Tomorrow's Tools Today," Vol. 5, No. 1, January 1939, pages 2 and 3 (Joint App. 181) discloses a typical example of well drilling, logging, casing running, cementing, and perforating. It discloses cementing at two spaced elevations. It teaches that a productive area should not be cemented, so that the casing can be readily perforated at that area and the flow brought in free from interference from cement.

SUMMARY OF ARGUMENT

1. The question of invention over the prior art in a case of this character is a question of fact, and not a question of law.

2. The judgment of the District Court should not be disturbed if the evidence affords a rational basis for the judgment.

3. Appellant's alleged invention, so far as claims 12 and 14 are concerned, is claimed to reside in the novelty of the concept of simultaneously measuring at

various depths within fluid in the well bore the combined electrical characteristics of the fluid and the surrounding formations, that is, electrically logging the well bore, and measuring the variations in the diameter of the well bore at the various depths, and correlating the log readings obtained with the variations in diameter to determine the effect on the log readings of the variations in diameter as ascertained. It being old in the art to electrically log a well bore, and also old to measure the diameter of a well bore at various depths (as appellant concedes), it is submitted that the finding of lack of invention in doing these two things *simultaneously,* as claimed in claims 12 and 14, is amply supported by the evidence presented in appellee's exhibits B, D, E, G, and H, each one of which teaches that different values commonly investigated in a well bore may be investigated *simultaneously* and in the same location in the well bore.

4. Appellant's alleged invention, so far as claims 13, 16, 17, and 18 is concerned, is claimed to reside in the utilization of the information obtained from the logging procedure, just discussed, ~~is~~ in cementing a casing in the bore of the well. After positioning a casing in the bore, cement may be introduced between the casing and the bore, above and below the area of a productive formation as indicated by the log. Thereafter the casing is perforated at the indicated formation. The finding of lack of invention in these features relating to cementing the casing in the well bore is submitted to be amply supported by the evidence offered in appellee's exhibits E and I.

5. The citation of numerous authorities in appellant's brief of cases where invention was found over the prior art, on facts differing from those of the case at bar, is not even persuasive, much less convincing, of any error in the findings of fact of the District Court in the case at bar, based upon the evidence before the District Court.

6. The patent to Bays, a copy of which is attached to appellant's brief, and which is referred to at pages 30, 31, and 32 of appellant's brief, with the argument (appellant's brief, 30) that "the appellee is not consistent in his actions" is submitted to have no relevance to the issue raised by this appeal.

ARGUMENT

1. In a case of this character the question of invention over the prior art is a question of fact, and not a question of law. The District Court properly placed the findings on the question of invention under findings of fact (Joint App. 12 to 14) and not under conclusions of law (Joint App. 14). *Minnesota Mining & Manufacturing Co.* v. *Coe,* 75 U. S. App. D. C. 131; 125 F. (2d) 198.

2. The judgment of the District Court should not be disturbed if the evidence affords a rational basis for the judgment. *Abbott et al.* v. *Coe,* 71 App. D. C. 195, 109 F. (2d) 449; *Radtke et al.* v. *Coe, et al.,* 74 App. D. C. 25, 122 F. (2d) 937; *Morgan* v. *Daniels,* 153 U. S. 120; *Wolf et al.* v. *Coe,* 72 App. D. C. 224, 112 F. (2d) 847; *Krause* v. *Coe,* 74 App. D. C. 47, 120 F. (2d) 717.

3. As to claims 12 and 14, although appellant concedes that it was old to log a well bore electrically, and also old to take reading of well diameter, nevertheless appellant presents the argument at page 20 of his brief that "Never before in the history of the art had such simultaneous readings been taken."

It is conceded that the prior art relied upon by appellee does not show that the particular readings of claims 12 and 14 have been taken *simultaneously*. Thus the subject matter of claims 12 and 14, on the record presented, is *novel*. But neither novelty or utility or both together is sufficient to establish the right to the patent sought unless it appears that there was invention involved. *Cuno Engineering Corporation* v. *The Automatic Devices Corporation*, 314 U. S. 84.

In deciding whether there is invention over the prior art, the fact that claims 12 and 14 do not read upon one patent or publication taken alone is immaterial. Whether there is invention over the prior art can be ascertained only by first investigating what is the prior art, and that investigation is not confined to a single patent, or publication, or use, but the conclusion may be based on the knowledge derived from several publications or uses. *Magnaflux Corp.* v. *Coe*, 78 U. S. App. D. C. 258, 139 F. (2d) 531.

Had no one ever taken simultaneous readings in a well bore of two different values, there might be some force to appellant's hereinbefore quoted argument from page 20 of his brief. But on the record here presented appellant is not the first one to take simultaneous readings of values in a well bore. As found by the District Court in finding of fact 4 (Joint App. 13) each of the patents to Bazzoni et al. 2,167,630, Ennis 2,228,623, Ennis 2,317,039 and Lee 2,313,384, teaches that different values commonly investigated in a well bore may be investigated simultaneously, and in the same location in the well bore, by means of a single cable, with indicating apparatus located in an electrode carrier within the well, or at the earth's surface. This state of the prior art is submitted to be ample evidence to support the finding of fact 11 (Joint App. 14) that there is no patentable significance to the step of correlating electrical readings and diameter readings taken along the bore to locate productive areas. The same evidence is submitted amply to support finding of fact 12 (Joint App. 14) that there is no invention involved over the prior art in *simultaneously* taking two particular readings, the step of taking each of which readings is old in the prior art.

It is therefore respectfully submitted that appellant has not sustained the burden of showing any error in the judgment of the District Court as to want of invention in the subject matter of claims 12 and 14 over the evidence of the prior art as presented by appellee.

4. Of the claims involved in this appeal there remain to be discussed here those in the second group, viz, 13, 16, 17, and 18, of which appellant paraphrases at page 35 of his brief claims 13 and 17 as "representative of this group of claims." As there is no separate discussion of claims 16 and 18, it seems

to be conceded that they stand or fall with claims 13 and 17, and therefore no separate discussion of them appears to be necessary here.

It is said at page 34 of the appellant's brief that "Claims 13, 16, 17, and 18 here on appeal are also method claims for the further detailed procedure invented by Smith, utilizing the invention of the simultaneous electric log and caliper log to thereafter proceed with the setting the casing, introducing cement above and below the productive area and then perforating the casing to complete the well."

It has hereinbefore been shown in discussing claims 12 and 14, wherein the District Court found as a fact, correctly it is submitted, that there is no invention over the prior art in the "simultaneous electric log and caliper log" alluded to in appellant's hereinbefore quoted statement. This covers feature (a) of claim 13 as printed at page 35 of appellant's brief. Feature (b) of the same claim is "positioning a casing within the bore." There is clearly nothing novel in this feature by itself, as shown by either finding of fact 7 or 8 (Joint App. 13).

The feature (c) of claim 13 as paraphrased at page 35 of appellant's brief is submitted not to impart patentability. The District Court expressly found as a finding of fact (9) (Joint App. 14) that it would not amount to invention to measure the diameter of the bore where the cement is to be applied to ascertain what quantity of cement to use. The District Court also found as a finding of fact 8 (Joint App. 13) that the publication "Tomorrow's Tools Today" (Joint

App. 191) discloses cementing at two spaced elevations, and teaches that a productive area should not be cemented. The District Court also expressly found in finding of fact 10 (Joint App. 14) that it would not amount to invention to omit cementing a productive washed out area between the casing and the well bore. The feature (d) of claim 13 as stated by appellant at page 35 of his brief viz, "thereafter perforating the casing at said indicated formation" obviously involves no invention over the state of the prior art as found by the District Court in findings of fact 7 and 8 (Joint App. 13).

Claim 17, as analyzed at pages 35 and 36 of appellant's brief contains no feature not already discussed in connection with claim 13, so no further discussion of this claim here appears to be necessary.

5. The numerous authorities cited in appellant's brief of cases where invention was found to be present, do not, it is submitted, in any way indicate error as to the findings of fact as to the lack of invention in the subject matter of the claims here involved over the prior art introduced in evidence by the appellee. The case of *General Electric Co.* v. *DeForest Radio Co.*, cited by appellant at page 40 of his brief as appearing at "37 U. S. P. Q. 67" does not appear in Vol. 37, but is found at 7 U. S. P. Q. 67, and is also reported at 44 F. (2d) 93. It is interesting to note that the holding of the Circuit Court of Appeals, as to invention, based upon the language quoted at page 40 of appellant's brief, was reversed by the U. S. Supreme Court on certiorari, the latter tribunal hold-

ing that there was no invention over the prior art. *DeForest Radio Co.* v. *General Electric Co.,* 283 U. S. 664.

6. At pages 30 to 32 of appellant's brief reference is made to a patent to Bays attached to his brief. It is urged at page 30 of appellant's brief that the patent to Bays is an illustration that "the appellee is not consistent in his actions." Assuming, for argument only, that the quoted allegation were correct, it would have no bearing on the issue here to be decided, since it would not show that either the action of the Patent Office or of the District Court with respect to appellant's application here involved was wrong. *In re Lee et al.,* 31 C. C. P. A. 768, 139 F (2d) 717.

The argument is made at page 31 of appellant's brief that claims have been granted by the Patent Office to Bays "while refusing claims to Smith directed to the same invention." However, it is at once obvious that the claims of the Bays' patent and the claims here involved are not "directed to the *same* invention," as alleged by appellant. There are only 2 claims in the Bays' patent. Neither one of these two claims of Bays includes any of the features relating to cementing a well, all as included in appellant's claims 13, 16, 17, and 18, as hereinbefore discussed. Neither do the two remaining claims involved in this appeal, viz. 12 and 14, relate to the "*same* invention" as claimed in the two claims of the Bays' patent. A mere reading of the two claims of the patent to Bays at once reveals that each claim includes a limitation to producing two voltages and "producing an indication proportional to the difference in said voltages" (claim 1) or "applying the difference in said voltages to a variable impedance" (claim 2). This feature claimed by Bays of the "difference in said voltages" is obviously not involved in either one of appellant's claims 12 and 14. Appellant does not even allege that such subject matter is disclosed in his application. It therefore seems abundantly clear that the patent to Bays contains no claims directed to the *same* subject matter involved in the appealed claims. It is therefore submitted that the patent to Bays is of no relevance to any issue here involved.

CONCLUSION

It is respectfully submitted that the claims involved on this appeal were rightly held to lack invention over the prior art cited for the reasons explained by the examiners in their statements, affirmed by the Board of Appeals and sustained by the judgment of the District Court.

In consequence, it is therefore respectfully submitted that the judgment of the District Court, from which appeal has been taken, is correct and should be affirmed.

Respectfully submitted.

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Attorney for Appellee.

H. S. Miller,
Of Counsel,
January 1947.

U. S. GOVERNMENT PRINTING OFFICE: 1947

No. 9399

JOINT APPENDIX TO BRIEFS

United States Court of Appeals

DISTRICT OF COLUMBIA

United States Court of Appeals
for the District of Columbia

FILED FEB 1 1947

Joseph W. Stewart
CLERK

ALONZO L. SMITH,
Appellant,

vs.

CASPER W. OOMS, COMMISSIONER OF PATENTS,
Appellee.

**Appeal from the District Court of the United States
for the District of Columbia**

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Plaintiff's Exhibit No. 2—Drawing—Smith invention in position in a well bore 193

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Defendant's Exhibits A to N, inclusive, as follows:

Patent Number

A—Allen, et al 1,946,924 124

B—Huber, 2,072,950 130

C—Kinley, 2,102,080 138

D—Bazzoni, et al 2,167,630 143

E—Ennis, 2,228,623 154

F—Kinley, et al., 2,267,110 165

G—Lee, 2,313,384 170

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United States Court of Appeals

DISTRICT OF COLUMBIA

No. 9399

ALONZO L. SMITH,
Appellant,

vs.

CASPER W. OOMS, COMMISSIONER OF PATENTS,
Appellee.

Appeal from the District Court of the United States for the District of Columbia

JOINT APPENDIX TO BRIEFS

IN THE DISTRICT COURT OF THE UNITED STATES

FOR THE DISTRICT OF COLUMBIA

CIVIL ACTION NO. 30662

FILED

Sep 17 1945

CHARLES E. STEWART, Clerk

ALONZO L. SMITH, in his own right,
2200 Gulf Building,
Houston, Texas,
Plaintiff,

v.

CASPER W. OOMS,
Commissioner of Patents,
U. S. Patent Office,
Washington, D. C.
Defendant.

Suit to Enforce Issuance of a Patent
Bill of Complaint

The plaintiff states as follows:

I.

The plaintiff, Alonzo L. Smith, a citizen of the United States and a resident of Houston, in the County of Harris, State of Texas, brings this suit in his own right.

II.

The defendant, Casper W. Ooms, is the Commissioner of Patents of the United States, a legal resident of the District of Columbia, and is sued as Comissioner of Patents of the United States.

III.

The bill is filed in accordance with the provisions of Federal Laws of the United States as provided for under Revised Statutes, Section 4915.

IV.

43 The plaintiff brings this suit in his own right as owner of the entire right, title and interest in and to United States application for patent, Serial No. 411,761, filed September 20, 1941, for WELL SURVEYING DEVICE AND METHOD.

V.

The patent application was filed in accordance with the laws of the United States and the Rules of the Patent Office.

VI.

The said application has been duly prosecuted in accordance with the laws of the United States and the rules of the Patent Office.

VII.

The said application has been passed upon by the Primary Examiner, who refused to allow the following claims:

Claim 8: In a well surveying device the combination of a housing adapted to be lowered within a well, caliper arms pivotally attached to said housing, means normally urging said arms resiliently outwardly into engagement with the walls of the well, a variable capacitance within said housing, means operable by movements of said rod for varying said capacitance, and means at the mouth of the well bore and electrically connected to said capacitance for exhibiting the variations in the capacity thereof as a measure of the diameter of the well bore.

Claim 9: In a well surveying device, a housing adapted to be lowered into a well bore, a rod extending outwardly from within the housing, means for moving said rod in accordance with variations in the diameter of the well bore, a coil within the housing, means for supplying an alternating current to said coil, a second coil within said housing and movable by said rod, and means for measuring the variations in the inductive coupling between said coils as a measure of the variations in the diameter of the well bore.

Claim 10: In a well surveying device, a housing adapted to be lowered into a well bore, caliper arms pivotally attached to said housing and movable outwardly into engagement with the walls of the bore, a rod in said housing attached to and movable by said rods, a coil, a source of alternating current connected thereto, a second coil mounted on said od and movable inductively relative to the first mentioned coil, and means for measuring the inductive coupling between said coils.

Claim 11: In a well surveying device, a housing
44 adapted to be lowered into a well bore, caliper arms pivotally attached to said housing and movable outwardly into engagement with the walls of the bore, a rod in said housing attached to and movable by said rods, a pair of coils in said housing, one of said coils being fixed and the other being movable by said rod to vary the coupling between the coils, a source of alternating current for one of the coils, and means for measuring the variations in the coupling between the coils as a measure of the variations in the diameter of the well bore.

Claim 12: The improvement in the art of investigating geological structure penetrated by a well bore which comprises the steps of simultaneously, measuring at various depths within fluid in the well bore the combined electrical characteristics of the fluid and the surrounding formations, and measuring the variations in the diameter of the well bore at the various depths, and correlating the log reading obtained with the variations in diameter to determine the effect on the log readings of the variations in diameter as ascertained.

Claim 13: In the art of obtaining information for the preparing an earth bore for the production of petroleum the steps of, simultaneously electrically logging and measuring the variations in the diameter of the bore so as to obtain information of the electrical characteristics of the earth formations penetrated by the bore and to correct such information as it may be varied due to variation in the diameter of the bore, positioning a casing within the bore, introducing an amount of cement as indicated by the diameters measured which will effect the cementing of the casing above the area and below the area of productive formation as indicated by the log, and thereafter perforating the casing at said indicated formation.

Claim 14: In the art of formulating an electrical log of an open well bore where the indications obtained are affected by diameter of the column of drilling mud or liquid in the well bore, the step of obtaining electrical logging readings and simultaneously therewith obtaining a measurement of the diameter of the bore at the elevation at which the readings are being taken, and correcting the reading obtained for variations thereof caused by variations in diameter of the column of liquid logged because of the variations in the diameter of the bore.

Claim 16: A method of obtaining penetration of the shot into a productive formation in a well bore where the formation is washed out to a larger diameter than the bore during drilling by excluding such area from cementing which comprises calipering the well bore to ascertain the location, presence, diameter and extent of the washout, running a casing into the well, cementing the casing at spaced elevations above and below the washed out area so as to avoid filling the washout with cement which might not be penetrated by the shot, and shooting the casing to form perforations therein at the non-cemented area at the elevation of the washout.

Claim 17: A method of obtaining penetration of the shot into a productive formation in a well bore where the formation is washed out to a larger diameter than the bore during drilling by excluding such area from cementing which comprises calipering the well bore to ascertain the location, presence, diameter and extent of the washout, running a casing into the wall, cementing the casing at spaced elevations above and below the washed out area so as to avoid filling the washout with cement which might not be penetrated by the shot, shooting the casing to form perforations therein at the non-cemented area at the elevation of the washout, and simultaneously on the same calipering device supporting an electrical logging mechanism to determine the nature and characteristics of the washout out formation.

Claim 18: A method of obtaining penetration of the shot into a productive formation in a well bore where the formation is washed out to a larger diameter than the bore during drilling by excluding such area from cementing which comprises calipering the well bore to ascertain the location, presence, diameter and extent of the washout, running a casing into the well, cementing the casing at spaced elevations above and below the washed out area so as to avoid filling the wash out with cement which might not be penetrated by the shot, shooting the casing to form perforations therein at the non-cemented area at the elevation of the washout, simultaneously on the same calipering device supporting an electrical logging mechanism to determine the nature and characteristics of the washed out formation, and correcting the determination of such logging mechanism for variation due to the presence of an additional volume of drilling mud or liquid in the washed out area.

Claim 19: In the art of preparing an earth bore for the production of petroleum the steps of, lowering an apparatus into the well bore which is capable of simultaneously electrically logging and measuring the variations in the diameter of the bore so as to obtain information of the electrical characteristics of the earth formations penetrated by the bore and correcting such logging information as it may be varied due to variation in the measured diameter of the bore.

which he finally rejected in accordance with the Rules of the Patent Office.

VIII.

An appeal was taken from the decision of the Primary Examiner to the Board of Appeals, who affirmed the rejection of the Primary Examiner in a decision dated March 22, 1945.

IX.

The Commissioner of Patents, by the Board of Appeals, contends that the applicant's WELL SURVEYING DEVICE AND METHOD as recited in the claims thereof is shown in the following references:

Ennis	2,228,623	Jan. 14, 1941
Ennis	2,317,039	Apr. 20, 1943
Kinley	2,102,080	Dec. 14, 1937
Kinley, et al	2,267,110	Dec. 23, 1941
Allen	1,946,924	Feb. 13, 1934
Bazzoni et al	2,167,630	Aug. 1, 1939
Lee	2,313,384	Mar. 9, 1943
Huber	2,072,950	Mar. 9, 1937

"Tomorrow's Tools Today"—Volume 5, No. 1,

Jan. 1939, P. 2 and 3.

and as being substantially met thereby and unpat-
46 entable over such patents when considered alone or
in combination with each other.

The ground of refusal as to Claim 8 was that such claim was directed to a non-elected species which the defendant inadvertently required of the plaintiff.

Claims 9, 10, and 11 were refused to the plaintiff in view of the patent to Allen.

The ground of refusal of claims 12, 14, and 19 was in view of either Kinley patent, either Ennis patent, the Bazzoni patent, or the Lee patent.

Claims 13, 16, 17, and 18 were refused in the light of the publication "Tomorrow's Tools Today" in view of Bazzoni and the Kinley patents.

X.

The applicant disagrees with these contentions of the Commissioner of Patents and contends that none of these references discloses, describes or suggests changes such as called for by the claims and that invention is involved in the construction specified by the claims and that the remaining contentions of the Commissioner of Patents are improper.

XI.

The Primary Examiner and the Board of Appeals disagreed as to some of the grounds of rejection in that the Board of Appeals reversed the Examiner on his rejection that the claims were unsupported by the disclosure. The Board of Appeals also reversed the Examiner on his holding that claims 16, 17, and 18 were indefinite, holding that the claims were not objectionable. The Board of Appeals also reversed the Examiner in holding that claims 16, 17, and 18 were not aggregational.

Claim 7 has been allowd to the applicant, indicating that the application discloses his invention.

XII.

47 Plaintiff further states that said invention is new and useful, was not known or used by others in this country before his invention thereof, and not patented or described in any printed publication in this or in any foreign country before his invention thereof, or more than one year prior to his application for patent thereof, and not in public use or on sale in this country for more than one year prior to said application, and not patented in any foreign country by him or his legal representative on an application filed more than twelve months prior to said application for United States patent and not abandoned.

WHEREFORE, the plaintiff prays that the Honorable Court decree that the Commissioner of Patents be directed to allow the said claims and such other claims as upon hearing the Court may find patentable, and that the Commissioner of Patents appear and answer this complaint, but not under oath, answer under oath being hereby expressly waived.

ALONZO L. SMITH
Plaintiff, in his own Right.

By LESTER B. CLARK

EMMETT L. SHEEHAN,
Bond Building,
Washington, D. C.

LESTER B. CLARK,
2200 Gulf Building,
Houston, Texas.

• • •

48 ANSWER TO THE COMPLAINT

To the Honorable the Justices of the District Court of the United States for the District of Columbia.

I. Defendant admits the allegations of paragraph I.

II. He admits that he is the Commissioner of Patents and that he is sued in his official capacity as such. He denies that he is a legal resident of the District of Columbia. He states that his official residence is in the District of Columbia.

III, IV, V, VI, VII, VIII. He admits the allegations of paragraphs III to VIII, inclusive.

IX. He admits that the Board of Appeals in its decisions of March 22, 1945, and April 28, 1945, held unpatentable claims 8 to 14, inclusive, and claims 16 to 19, inclusive, of plaintiff's patent application No. 411,761, entitled "Well Surveying Device and Method," and
49 that said holding was made in view of the following prior patents and publication:

Ennis,	2,228,623,	January	14, 1941,
Ennis	2,317,039,	April	20, 1943,
Kinley,	2,102,080,	Dec.	14, 1937,
Kinley et al.,	2,267,110,	Dec.	23, 1941,
Allen,	1,946,924,	Feb.	13, 1934,
Bazzoni et al.,	2,167,630,	Aug.	1, 1939,
Lee,	2,313,384,	March	9, 1943,
Huber,	2,072,950,	March	9, 1937,

"Tomorrow's Tools Today"—Volume 5,
No. 1, Jan. 1939, pages 2 and 3.

Profert of copies of these patents and publication is hereby made. He admits that one ground of refusal of claim 8 was that it is directed to a non-elected species of the alleged invention. He denies that the requirement for election was inadvertently made. He admits that said claims were refused for the reasons set out in paragraph IX. He states that said claims are unpatentable for said reasons and for other reasons set out in the statements of the examiners in answer to the appeal and the decisions of the Board of Appeals, copies of which will be furnished at the trial.

X. He admits that plaintiff disagrees with the decisions of the Board of Appeals and that plaintiff makes the contentions set out in paragraph 10, but defendant denies such contentions.

XI. He admits that the Board of Appeals disagreed with some of the grounds of rejection urged by the examiners and reversed their rejection that certain claims were unsupported by plaintiff's disclosure. He admits that the Board of Appeals also reversed the examiners' holding that claims 16, 17 and 18 were for an aggregation. He admits that claim 7 of the application was allowed to plaintiff and that the allowance thereof indicates that the subject matter of said claims is disclosed in said application. He denies that the Board of Appeals reversed any holding by the examiners that claims 16, 17 and 18 are indefinite.

XII. He admits that in said application plaintiff made averments corresponding to the allegations of paragraph XII, but denies, for reasons aforesaid, that such allegations would justify the issuance of a patent containing any of the claims of the application which are set out in paragraph VII.

W. W. Cochran
Solicitor, U. S. Patent Office,
Attorney for Defendant.

* * *

51 *Informal Memorandum*

At the trial plaintiff withdrew claims 8, 9, 10, 11, 19, leaving only claims 12, 13, 14, 16, 17, 18 all of which relate to a method or process.

The court holds that the plaintiff has failed to show invention. On the contrary the evidence convinces the court that the Patent Office was correct in holding that invention is not shown in the claims in view of the conceded prior art patents which were received in evidence.

The defendant will submit appropriate findings of fact, conclusions of law and a judgment form dismissing the complaint.

F. Dickinson Letts
Justice

* * *

52 *Findings of Fact*

1. This is an action under R. S. 4915 (U.S.C., title 35, sec. 63) in which the plaintiff, Alonzo L. Smith, sought to have the Court authorize the allowance of claims 8 to 14, inclusive, and 16 to 19, inclusive, of his application Serial No. 411,761 for well surveying device and method.

2. At the trial plaintiff withdrew claims 8, 9, 10, 11, and 19.

3. The plaintiff's application here involved relates to a well surveying device and method and discloses a device used in carrying out a process of simultaneously measuring at various depths within fluid in the well bore the combined electrical characteristics of the fluid and the surrounding formations, that is, electrically logging the well bore, and measuring the variations in the diameter of the well bore at the various depths, and correlating the log reading obtained with the variations in diameter to de-

termine the effect on the log readings of the varia-
53 tions in diameter as ascertained. From this logging
procedure information is obtained as to a productive area in the well, and after positioning a casing in the bore, cement may be introduced between the casing and the bore, above and below the area of a productive formation as indicated by the log. Thereafter the casing is perforated at the indicated formation.

4. Each of the patents to Bazzoni et al 2,167,630, Ennis 2,228,623, Ennis 2,317,039 and Lee 2,313,384 teaches that different values commonly investigated in a well bore may be investigated simultaneously and in the same location in the well bore, by means of a single cable, with indicating apparatus located in an electrode carrier within the well, or at the earth's surface.

5. Patents to Kinley, 2,102,080 and Kinley et al 2,267-110 illustrate known methods and means for securing logs of well diameter, from which the well contour may be determined and suitable information gained.

6. The patent to Huber 2,072,950 teaches a method of making simultaneous electrical tests, discusses incidentally the known effect of variation in the diameter of the bore hole, and makes an adjustment to compensate for difference in diameter.

7. The patent to Ennis 2,228,623 discloses running an electric log in an open hole, cementing in a casing and thereafter perforating the casing with a gun.

8. The publication "Tomorrow's Tools Today," Vol. 5, No. 1 January 1939, pages 2 and 3, discloses a typical example of well drilling, logging, casing running, cement-
ing and perforating. It discloses cementing at two
54 spaced elevations. It teaches that a productive area
should not be cemented so that the casing can be

readily perforated at that area and the flow brought in from interference from cement.

9. It would not amount to invention to measure the diameter of the bore where the cement is to be applied to ascertain what quantity of cement to use.

10. It would not amount to invention to omit cementing a productive washed out area between the casing and the well bore.

11. There is no patentable significance in the step of correlating electrical readings and diameter readings taken along the bore to locate productive areas.

12. There is no invention involved over the prior art in simultaneously taking two particular readings, the step of taking each of which readings is old in the prior art.

13. None of claims 12, 13, 14, 16, 17, and 18 of the application here involved defines invention over the prior art.

14. Each of claims 12, 13, 14, 16, 17, and 18 of the application is unpatentable in view of the prior art.

Conclusions of Law

1. The plaintiff is not entitled to a patent containing any of the claims set forth in the complaint.

2. The complaint should be dismissed as to all the claims involved.

F. Dickinson Letts
Justice.

* * * *

55 *Order*

This action came on to be heard at this term and thereupon, upon consideration thereof, it is, this 15th day of April, 1946, ADJUDGED that the complaint in this case be, and the same hereby is dismissed with costs against the plaintiff.

F. Dickinson Letts
Justice.

* * * *

57 *Statement of Points*

1. The Court erred in holding that it would not amount to invention to measure the diameter of the bore where the cement is to be applied to ascertain what quantity of cement to use.

2. The Court erred in holding that it would not amount to invention to omit cementing a productive washed out area between the casing and the well bore.

3. The Court erred in holding that there is no patentable significance in the step of correlating electrical readings and diameter readings taken along the bore to locate productive areas.

4. The Court erred in holding that there is no invention involved over the prior art in simultaneously taking two particular readings, the step of taking each of which readings is old in the prior art.

5. The Court erred in holding that none of claims 12, 13, 14, 16, 17 and 18 of the application, Serial No. 411,761 for well surveying device and method defines invention over the prior art.

6. The Court erred in holding that each of claims 12, 13, 14, 16, 17 and 18 of the application, Serial No. 411,761 is unpatentable in view of the prior art.

58 7. The Court erred in failing to authorize the issuance of a patent under R. S. 4915 (U. S. C., title 35. sec. 63) covering claims 12, 13, 14, 16, 17 and 18 of application, Serial No. 411,761, for well surveying device and method.

8. The Court erred in concluding that the plaintiff is not entitled to a patent containing any of the claims set forth in the complaint.

9. The Court erred in concluding that the complaint should be dismissed as to all the claims involved.

10. The Court erred in ordering that the complaint be dismissed, with costs against the plaintiff.

Emmet Leo Sheehan
Lester B. Clark
223 Bond Bldg.,
Washington, D. C.

Attorneys for Plaintiff.

* * * *

18 *Evidence on Behalf of the Plaintiff*

Thereupon—

Karl Fenning,

called as a witness on behalf of the plaintiff, having been first duly sworn, was examined and testified as follows:

Direct Examination

BY MR. CLARK:

Q. Will you please state your name, age, residence and occupation? A. Karl Fenning, 64, patent lawyer, Washington, D. C.

Q. What is your training and qualification in patent matters, Mr. Fenning? A. After graduating from college and two law schools, I began the practice of patent law. I have practiced for upwards of 40 years in New York, Cleveland and in Washington.

President Harding appointed me assistant Commissioner of Patents, and I remained in that position for a little over four years.

Throughout my 40 years I have had to examine, interpret and explain hundreds of patents.

Q. Have you gone over the Smith application and the prior art patents which are being relied upon by the Patent Office in this particular case, Mr. Fenning? A. I have.

MR. CLARK: You Honor, in view of the explan-
19 ation which I gave in my opening statement, I am
wondering if you would want me to go into a further explanation with Mr. Fenning as to Smith's operation, or whether Your Honor had any questions in connection with it. I thought maybe I might omit that, and just go directly to the references relied on by the Patent Office.

THE COURT: I rather think you made that plain. Do you see any reason for further elaboration on it?

MR. MILLER: No, Your Honor, I do not.

MR. CLARK: If Mr. Miller has no objection. I just wondered if he had any objection to the explanation I made. I tried to give it as clearly as I could.

MR. MILLER: I understand that is merely an attorney's argument. That is not evidence.

MR. CLARK: That is perfectly all right.

MR. MILLER: His application, as I understand it, is correct, is an explanation of the applicant's invention.

MR. CLARK: Plaintiff would like to offer in evidence as Plaintiff's Exhibit 1 a photostatic copy of the Smith application for patent as it is on file at the Patent Office. We will produce that and bring it in. We have it ordered.

MR. MILLER: All right.

MR. CLARK: I would like to offer, just as an illustration which was used in explaining the invention to the Court the drawing as Plaintiff's Exhibit 2, showing

20 the invention of Smith in position in a well bore, and as Plaintiff's Exhibit 3 the illustrative drawing of the well bore with the casing in position and the gun perforator ready to perform the perforating operation.

MR. MILLER: I have no objection to the illustration or sketch, merely as illustrating the attorney's argument.

MR. CLARK: That is the purpose of this.

(The documents referred to were marked "Plaintiff's Exhibits Nos. 1, 2 and 3," and received in evidence.)

BY MR. CLARK:

Q. I hand you a copy of Claims 12 and 14, which are two of the claims on appeal relating to the procedure for simultaneously taking the reading of the logging and the measure of the diameter.

Have you gone over those claims, Mr. Fenning? A Yes, sir.

Q. The Patent Office is relying upon certain exhibits which apply to these claims which are the defendant's Exhibits B through H, I believe. A. H.

Q. I would like to have you just run through those patents and give a general statement of the disclosure of each one of those as applying to those Claims 12 and 14 which you have. A. These patents are fairly voluminous, 21 running to six or eight or ten pages. They contain a good deal of detail, including electrical diagrams and wirings, and electrical theory and operation. It seems to me that it will not be necessary to go into them in very great detail but, rather, to explain generally what each patent purports to do in a more or less general way.

The Huber patent is a patent which apparently perceives that the mud in the well may seep into certain portions of the earth, the more or less porous formations. As shown in Figure 3, the extra shading around the edge of the well is intended to indicate that mud has seeped into the oil sand.

In the middle of Figure 2 are two little oblong blocks, each supported by a cable. These are separated, one above the other. The patent says they may be from 2 to 15 feet apart.

The Huber patent puts these two devices down at the same time. They are suspended on separate cables. There may be a divergence of their stretching, and while they may leave the surface of the ground from 2 to 15 feet apart, one cable may extend more than the other cable in the 10,000 or 15,000-foot depth. The result may be that the distance between those electrodes may be less than the original distance, or may spread out into more than the original distance apart.

He connects one of those electrodes on the suface of the earth very near to the opening of the well. The 22 other electrode is connected and read, logged, at a considerable distance from the surface of the well, the idea being that the first electrode may go through the oil sand only where it is saturated with mud, and consequently may not give an identification of the oil sand.

The other electrode current, however, stretched further out, may get beyond the deposit of mud in the sand, that is, it may get beyond the circles which are shown in the drawing, and therefore it may go through the oil sand.

By correlating by means that are known, the two readings, it is possible to determine whether the devices really are at an oil sand, or at a shale.

Q. Figure 2 shows a comparison of those two lines, does it not, Mr. Fenning? A. Figure 2 shows a comparison of the readings which may be gotten by this means, and Figure 2 not only shows the two readings but also shows in the side, the left-hand side, the equivalent formation in the well, showing the difference which may be obtained at different points.

It will be noted that towards the bottom on the line just above the line marked Figure 4200, the oil sand neighborhood, one of the lines extends to the left suddenly, while the other extends to the right suddenly. That is put in to show the difference between the effect of the current going through the mud saturated oil sand, and the current going through a straight oil sand, or out into the
23 oil sand.

Q. The gist of that patent, then, is the taking of two electric logs at about the same elevation at about the same time? A. That is so with the limitation that these electrodes being separately supported may not be at the same point.

Q. Is there anything at all in that patent regarding the measuring of the diameter of the well bore with the calipering tool? A. There is nothing to measure that, and apparently there is nothing to account for that in the readings of the log.

Q. What is your next? A. You want me to take them together?

Q. You might as well explain the Kinley patent, and the Court will understand one of the calipering devices. You might explain both the Kinley patents next, if you please. A. There are two Kinley patents, one Exhibit C, and the other Exhibit F. Each of these patents has a cable device which is suspended by a single cable into the well. I won't go into the details of the device, because it is probably unnecessary to do so, but Figure 2, for instance, of Patent 2102080, which is Exhibit C, shows on Figure 1 of that patent arms extending from a cylinder, extending in the more or less center of the well. There are four of these arms that extend out, are pushed
24 out by springs against the sides of the wells in four

different directions, so that if the cylinder is propelled upward through the well, the extension of the arms varies with the side walls of the well. That variation is recorded on a chart which is carried in the cylinder itself, so that when the device reaches the top of the well the chart may be taken off, and show more or less of a diagram of the contour of the sides of the well.

Now, the second Kinley patent, Exhibit F, does the same thing in practically the same way, with the exception as shown in Figure 1 of that patent 2267110. The extending arms, instead of being pivoted at the top are pivoted both top and bottom and in the center, making an elbow arrangement, the elbow being pushed out against the side walls of the well. It is thus possible to caliper the well either going up or—either as the cylinder is dragged up, or as the cylinder is dragged down. Another means for recording the movement of the cylinder is adopting an electrical means.

Q. For the purpose of the record, would you mind reading Claim 12 into the record, so that we will hear just the substance of that claim? A. Claim 12 says:

"The improvement in the art of investigating geological structure penetrated by a well bore which comprises the steps of simultaneously measuring at various depths within fluid in the well bore, the combined electrical characteristics of the fluid and the surrounding formations, and measuring the variations in the diameter of the well bore at the various depths, and correlating the log reading obtained with the variations in diameter to determine the effect on the log readings of the variations in diameter as ascertained."

You will note that that provides for measuring within fluid in the well. That refers to the mud which is still in the well.

Q. After going over the prior patents, do you understand that an enlargement in the bore which would provide an additional diameter of mud would have an effect upon the electrical log reading which is taken? A. Quite.

Q. Directing your attention particularly again to the Huber patent, Exhibit B, and pointing to page 4, column 1, lines 22 to 40, inclusive.

Just state very briefly what that explains. A. Huber indicates there that he must adjust the caliper, which is the electrical means he has for establishing or taking the readings of the electrical current, which runs through the earth, that must be extended and varied in accordance with the amount of mud—with the opening in the well itself.

Q. What illustration does Huber give there?
26 A. Huber says that "If the sensitivity is adjusted to give good detail in a bore hole six inches in diameter, the same sensitivity adjustment when measurements are being made in a 12-inch hole will give little or no detail, and the total throw of the galvanometer would be so small that the breaks in the curve would be more or less masked and the location of the discontinuities in the strata would not be indicated definitely."

"In other instances the salinity of the fluid in the bore hole might be such as to give too great a throw to the galvanometer needle."

In other words, he perceived that variations in the content and size of the hole would interfere with the accuracy of his device. Q. He does not describe any of these washed out areas in his patent, however? A. He does not refer to those, no.

Q. Giving an explanation for how he would operate in a 6-inch hole, or how he would operate in another 12-inch hole? A. Quite.

Q. What is your next patent, Mr. Fenning? A. There are two patents to Ennis which may be looked at together.

They are Exhibit E and Exhibit H. The first Ennis patent,
2228623, has at the end of the cable, as shown in
27 Figure 6, for instance, a dual—I think 6 does not
show it. Just a minute.

Figure 3 shows two devices at the end of one cable, the device marked 69 is the electric log device. The device marked 68 is the so-called penetrator.

Q. Perforator? A. Perforator. That is a shooting device which shoots a hole in the casing to let the oil in.

In this patent Ennis suggests taking a log in the well without the casing. He then puts in the casing and takes a second log, compounds those two, and endeavors to locate the oil sands.

Then he puts in the device illustrated in Figure 31 as a logging device and the shooting device drops down, and when this third log indicates the oil bearing sand as having been reached, he operates a perforator and shoots through the pipe to allow the oil to come in from the surrounding sand.

Q. Does he make any mention at all of measuring the diameter of the well bore at any time, anywhere? A. He has nothing to do, he pays no attention to the diameter of the well bore, nor does he pay attention—does he even mention specifically the cement which is forced in around the casing.

It is obvious, if you will look at Figure 31, for instance,
that the device 68 may penetrate the pipe itself and
28 go directly into the oil shale. If it happens that
the surrounding cement is not too heavy to interfere with the penetrator and stop the penetrator.

Q. If the oil sand happened to be washed out with oil and cement, do I understand he would get any production from his well? A. He would not get oil.

Q. His sole purpose is attempting to perforate at the same elevation where his log gives him an indication that he obtained an oil sand, is that correct? A. That is his purpose, but in passing I may call attention to the fact that it seems to be fairly well known in the art that a proper, satisfactory log can't be taken in the well after the casing has been put in. The iron or the casing interferes with the electric transmission.

Q. Does Ennis admit that? A. Ennis admits that by suggesting he takes one log before the casing and one afterward, and he shows samples of those varying to some extent.

The other Ennis patent, Exhibit H, No. 2317039 also has two devices suspended from a single cable, as illustrated in Figure 2.

The purpose of this patent is to discover whether there is a water infiltration and flow in the well itself, and to find out where that water is entering the well.

29 He therefore dropped the combined device, marked 23, which consists of an electric log, so as to let him know the character of the material adjacent to the device, and below that he has a device marked "Figure 31" through which he sends an electro-light which will enter into the mud and give the mud a different electrical conducting condition. Now, when water is flowing into the well the water will enter into that electro-light in the mud and dilute it, and will also change its position and force it up somewhat in the well, and by this device Ennis seems to think that he can determine where water is entering the well, and more or less the quantity and the speed of the flow of the water.

This patent makes no reference to any washing out or change in the site of the hole. He does not refer to the cementing of the pipe. He has nothing to do with penetration and knows nothing about the cross-section of the well at the various points.

Q. He gives no suggestion of measurement of the diameter of the well? A. He does not do that.

Q. It is a patent for merely using this light, not these other patents to show two simultaneous operations of some sort or another in the well bore? A. Yes.

Q. The Lee patent, I believe, is next. A. The
30 Lee Patent, which is Exhibit G, is of no more importance.

Lee has an electric log device at the bottom of which he puts a thermometer so that he may measure the temperature at the various points in the well, and apparently he uses that temperature to correct the reading of the electric logging.

Again, he makes no reference to the irregularity. He makes no measurement, no calipering of the contour of the well. He makes no mention of the variation in size, takes no account of those, and makes no mention of the perforation or shooting, or of the effect thick cement will have on it.

Q. I think the last patent you have there is the Bazzoni patent. A. The Bazzoni patent, which is Exhibit D, 2167630, is likewise of very little interest.

Bazzoni has an electrical log device which merely determines the character of the ground through which the well goes.

It has the common defect of not being able to locate spots directly because of the indeterminate extension of the cable which supports it.

The only thing of importance or interest in this patent is on page 6, column 2, where Bazzoni says that "the apparatus disclosed herein is particularly well adapted for
operation in connection with a well surveying instru-
31 ment of the multiple shot type. This is by reason
of the fact that there is no necessity for running a

cable to the surface. The exploratory unit may be coupled directly below a well surveying instrument of the type, for example, of that described in Williston and Nichols Patent No. 1960038, dated May 22, 1934."

The Williston patent is a patent which may be referred to as a surveying instrument patent. Its purpose, however, is not to determine the contour or cross-section of the well, but to determine the inclination of the bore. Williston has an internometer, so-called, which measures as he goes through the well the deviation of the well from the direct perpendicular.

We have here, then, a device which at one time, or simultaneously, measures the inclination of the well, and the character, electrically measures the character of the land at the particular point in the well where the inclination is determined.

That has no suggestion of determining the contour or cross-section variations in the well. Nothing is said with respect to the cement being placed there, and no indication of the enlarged cement which will go into an expansion in the well and interfere with the perforating to let the oil into the casing.

Q. All of these patents that you have reviewed so far, then, merely show and are produced by the Patent Office
and used by the Examiners for the purpose of show-
32 ing that two operations of some sort— A. (Interposing) Yes.

Q. Have been made at the same time in a well bore? A. But that dual operation is not the same sort of dual operation as that of the applicant.

Q. None of them are the dual operation of logging and calipering the hole simultaneously? A. No.

Q. I direct your attention to the next group of claims.

Now, Claim 13 as an example, and I would like to have you read that claim into the record, if you will, please. A. Claim 13: "In the art of obtaining information for the preparing of an earth bore for the production of petroleum the steps of, simultaneously electrically logging and measuring the variations in the diameter of the bore so as to obtain information of the electrical characteristics of the earth formations penetrated by the bore, and to correct such information as it may be varied due to variation in the diameter of the bore, positioning a casing within the bore, introducing an amount of cement as indicated by the diameters measured which will effect the cementing of the casing above the area and below the area of productive formation as indicated by the log, and there-
33 after perforating the casing at said indicated formation."

The thing, in effect, which has been added by the claims, of course, is the introducing of the appropriate amount of cement so as to leave open, not cement, the area which produces oil, and then perforating the casing at that particular point.

That, of course, means that when the pipe is perforated at that point the shot does not have in any instance cement to go through, and certainly you never have sufficient cement to interfere with the perforating, but does mean when the pipe is perforated at the appropriate point, the oil will come into the casing.

Q. The Patent Office has been using as a ground for refusing that type of claim, Mr. Fenning, a publication entitled "Tomorrow's tools today," which is in evidence as Defendant's Exhibit I. Have you read that publication? A. Yes.

Q. Which applies to the claims? A. Yes.

Q. Will you give a brief explanation of it, sir? A. I think attention should be called to the fact that all of the apparatus which the applicant employs here is old apparatus, as is not usual in most inventions.

The inventor has invented practically nothing new. The bolts and nuts and such things which he uses are
34 old. When he uses an old device or a combination of devices in a new way to accomplish a new purpose he then has produced an invention. And here the claims relate not to an apparatus but method of conducting procedures in connection with an oil well. It is not surprising, therefore, to find that specific—maybe not specific—but, in general, the apparatus which he uses is old, and various types of apparatus might be used for carrying out this purpose.

Now, the Exhibit I possibly might be read into the record, at least as far as the text is of importance here.

Q. Can't we just have the operator copy that in, if you will? lease copy the first column on the left-hand side.

THE WITNESS: And half of the second column.

"This well had been produced between 3,624 feet and 3,708 feet. After several years, the liner had collapsed, and in attempting to repair it, tools had been lost and the well was plugged and abandoned. Upon the discovery of a deeper zone in the area, the program as shown in the sketch was outlined. A Kinzbach whipstock was set at 3,215 feet in the 8-5/8 inch casing and a window milled through. A 7-3/4 inch rotary hole was drilled to 5,208 feet. Occasional cores were taken and electrolog run. 6-5/8 inch casing with flush joint below 3,193 feet was run and cemented at 5,208 feet, with 150 sacks of cement.
35 A dual seal cementer had been placed in the 6-5/8 casing string at 3,725 feet. Upon completion of the lower cement job, the upper stage cementing was done with 175 sacks of cement. After cleaning out and testing, the zones as shown on the electro-log chart between 5,140 feet and

5,167 feet, and 5,181 feet and 5,204 feet were gun perforated. Initial production was F. 184-26.2-0.4 percent.''

Here is a case where an oil well had been dug to between 3,600 and 3,700 feet. The trouble developed in the oil well, and the apparatus to correct the trouble was lost in the well, and couldn't be retrieved, and as was not uncommon, the well was abandoned on that account.

Then it was discovered by neighboring operations, apparently, that while there was an oil sand at the 3,600 or 3,700 feet, there was also an oil sand very much deeper in the earth, and specifically at 5,200, about 5,100 or 5,200 feet was the new line.

Now, in order not to dig a completely new well for the 5,200 feet, the owner of this well dropped cement into the bottom of their 5,200 feet, approximately, filled up that and then went down to just above that cement, and by boring machine cut what they referred to as a window through the side of that pipe. Then they proceeded through that
window to dig the additional hole somewhat smaller
36 than the first hole for the 5,200 feet.

Q. Curved out through, and then going straight down? A. Yes.

Q. To avoid the jump that is in the bottom of the other hole, and possibly on down to the 5,200 feet level, where other wells had found there was another oil sand? A. Yes. Now, having done that, they proceeded to pour cement into this new boring, and forced it out the bottom, as was usual, so as to seal off the bottom of the well, and they also went up a considerable distance above the bottom of the well, punctured the pipe again, and forced out more cement, so as to get a top and bottom cement seal, leaving an open space in the bottom.

Then it is to be noted, however, that at the 5,208-foot depth they forced in 150 sacks of cement. That is, at the bottom of the well they forced in 150 sacks of cement which came out around the anulus and filled up.

Now, the anulus left there, that is the distance between the well bore and the pipe which was in the hole, was only 9/16 of an inch, the pipe being 6 and 6-5/8 inches.

Q. The hole was 7-¾? A. The hole was 7-¾ inches, yes.

Now, it is well known that 150 sacks of cement would force up the cement about 150 feet in that anulus, that is, it takes about a sack of cement to fill that anulus
37 one foot high.

That means that starting at 5,208 feet, that would come up to about 5,028 feet, being the sand around the bottom of this pipe—

Q. Cement? A. Cement. The oil, however, the oil sand was lower than this 5,208 feet, so that they had packed cement around the outside of the anulus in the oil region. It happened that that cement was a thin layer of cement, and when the perforator went down, it was strong enough to perforate not merely the pipe, but also the cement, and went into the oil bearing sand, and let the oil into the pipe, and it was drawn up.

Now, there is no suggestion of a survey of the well here to determine its diameter. There is no suggestion of appreciating the fact that a large quantity of cement would interfere with the penetration device, and there is no suggestion of leaving free and uncemented any portion of the pipe and the well which passes the sand bearing strata.

In other words, if it happened that there was an enlargement of the bore of the well at the oil bearing strata, these people would not have produced their oil, because they would not have had the applicant's invention.

Q. Well, would there have been very much mud circulated by these oil sands here when the bottom of the hole

was 5,208 feet, and the bottom of the oil sand was 5,208
feet? A. That may not have happened. That is,
38 there might not have been very much of a washout
there, and apparently there was not much of a wash-
out.

Q. They obtained oil, according to this. Is there anything in there that suggests the idea of avoiding cementing of the oil sands that were indicated in this description? A. I don't find anything there or in any other prior art indicating that particular thing or the other steps which applicant's process claims.

MR. CLARK: I believe that is all of the direct examination, Mr. Miller.

Cross-Examination

BY MR. MILLER:

Q. Mr. Fenning, have you ever seen carried out the process which is enumerated in Plaintiff's Claims 12 and 14? A. No..

Q. Or have you ever seen carried out the processes as enumerated in Claims 13, 16, 17, and 18 of the Plaintiff's application? A. No.

Q. Mr. Fenning, referring again to the Huber patent, Defendant's Exhibit B, in Figure 2 you were explaining two curves, 29 and 40. A. Yes, sir.

Q. As opposed to the matter on the left-hand side of
the diagram showing the character of the well.
39 However, as I recall, you said nothing of the mat-
ter on the right-hand of the diagram. What do
you understand those figures indicate- A. I think I did
refer to that right-hand diagram. The three irregular
shaped lines, as I understand it, are the indicated—

Q. (Interposing) Correct, Mr. Fenning, I think you did say something about the 29 and 40. The 3,900 and 4,000. I thought you said nothing of those. A. I did refer to 4,200, but those, as I understand it, are placed there as indications of the depth of the well at the particular point where the individual corresponding checks on the diagrams were taken.

Q. Then am I correct that you admit that Huber does plot a log with the depths of the well and show different electrical characteristics as shown by the curves 29 and 40? A. I don't think I got all your words. Will the stenographer read that, please?

(The question was read.)

Q. That is the intention of Huber, at least? A. He may not be accurate in his distance, because these two devices, while they can go at the same time, are suspended by separate cables which may stretch to different extents, to some extent, at least.

Q. And, Mr. Fenning, on this publication, "Tomorrow's tools today," which is— A. (Interposing) Exhibit I, I think.

Exhibit 1, he discloses, does he not, the cementing of the well at places where he does not want the oil to come through? A. With the exception that at the bottom he cements the well where he does want the oil to come through.

Q. But later perforates the cement? A. Yes.

MR. MILLER: That is all.

MR. CLARK: I think that is all, Your Honor.

I would like to have permission to submit the brief in two weeks, the same as we did in our case yesterday.

MR. MILLER: I would like to formally introduce Exhibits on behalf of the Patent Office, A to N.

(The documents referred to were marked "Defendant's Exhibits Nos. A to N, inclusive," and received in evidence.)

* * *

67 *Petition and Power of Attorney*

To the Commissioner of Patents:

Your petitioner, Alonzo L. Smith, a citizen of the United States, and a resident of Houston, in the County of Harris and State of Texas, whose postoffice address is c/o Mid-Continent Supply Co., P. O. Box 1246, Houston, Texas prays that Letters Patent may be granted to him for the improvement in Well Surveying Device and Method set forth in the annexed specification; and he hereby appoints LESTER B. CLARK, Registration No. 12,677, address 2200 Gulf Building, Houston, Texas, his attorney, with full power to act in matters of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent, and to transact all business in the Patent Office connected therewith.

Signed at Houston, in the County of Harris and State of Texas, this 2nd day of September, A. D. 1941.

Alonzo L. Smith

Specification

To All Whom It May Concern:

Be it known that I, Alonzo L. Smith a citizen of the United States residing at Houston, Harris County, Texas have invented a certain new and useful inprovement in Well Surveying Device and Method of which the following is a specification:

68 This invention relates to a method of and means for surveying well bores by determining the configuration of the wall of the bore at various elevations.

In the drilling of well bores by the rotary method, mud is circulated in the well bore to flush the cuttings out of the bore, cool the bit, overcome formation pressures, prevent sticking of the drill pipe, and aid in the rate of penetration by the hydraulic wash of the mud jetting out of the bit under high pressure against the formations.

The hydraulic wash by the drilling fluid of the formations sometimes causes considerable trouble in completing oil wells, especially when the petroleum formation is relatively soft such as a sand formation.. Mud pumped out through the bit under high pressure may wash out the formation for a considerable distance radially of the well bore, depending on the relative hardness of the formation, and hence cause an area of large diameter to be created.

Under present practices such conditions are now known to exist. Also under present practices an electric log survey is generally made of the well bore for geological information. Naturally such a cavity existing in a bore of small diameter is certain to cause an error in the resistivity or self potential log when the electrodes are moving through the cavity area, since a material portion of the reading obtained by the log would relate to characteristics of the mud filling the cavity and not to the characteristics of the formation about the well bore. If the well bore contour were known, a correction factor could be used for correcting the readings in accordance with variation in the size of the bore. At the same time, the variations in the contour of the well bore would be indicative of the relative hardness and extent of the various formations and hence information as to contour variations would additionally constitute a log of the well bore.

69 After a well is logged, casing is set therein and is cemented. During the cementing process, cement is pumped outside the casing and the cavity is filled with cement. The usual method of completing a well is to perforate the well casing at a designated formation with a gun or by a mechanical perforator which produces holes or slots in the casing. If the cavity which was filled by cement was in the formation to be produced, attempts to

perforate and complete the well at that level might be unsuccessful since the shots might not effect desired penetration through the casing and cement.. The operator not knowing that an attempt was made to perforate through a substantial thickness of solid cement rather than a thin wall thereof would conclude that the penetrated formation is non-productive. If the condition of the well bore as to diameter were known, in accordance with the present invention, an improved practice can be followed in well completion and thereby the difficulties above mentioned are eliminated.

It is the primary object of the invention to provide a method of and means for measuring the well bore diameter and comparing such measurements with relationship to depth with an electric log for correlation purposes and for making necessary corrections in the log to eliminate the effect of changes in the diameter of the well bore.

Another object of the invention is to measure the well bore diameter with relationship to depth and to associate such measurements with completing practices to be used under existing and known conditions.

Another object is to measure the well bore diameter with relationship to depth to provide a log which is a measure of the relative hardness of the penetrated formations and hence provides information of the nature and extent of the respective formations.

Still another object is to provide a means of recording volumetric capacities of a well bore with relationship to depth for cementing practices.

A further object is to measure the diameter of a well bore by utilizing the movement of a caliper to actuate electrical induction coupling means for obtaining desired measurements.

A still further object is to provide mechanism having two or more caliper logs connected to a common drive for providing a single measurement which is indicative of the well bore diameter.

Still another object is to provide means for measuring a well bore diameter by actuating a single drive to change the electrical resistance or impedances of a calibrated electric circuit.

Other and more specific objects of the invention will be apparent from the following description considered in connection with the accompanying drawings in which:

Fig. 1 is a schematic sectional view through a well bore illustrating the technique and one embodiment of apparatus of the invention;

Fig. 2 is a view similar to that shown in Fig. 1 but showing a modification of the measuring mechanism of the calipering element;

Fig. 3 is a sectional view showing a further modification of the calipering element;

Fig. 4 is a sectional view through a bore in the earth and illustrating perforating conditions encountered in present practice.

71 The reference character 1 represents a well bore which is formed by a bit of a given diameter but which bore is variable in diameter as above explained, an enlargement being shown at 2 as illustrative of this condition.

In accordance with the invention a surveying unit 3 is lowered in the bore hole 1 upon a conductor cable 4, the construction being such that desired measurements are made available at the mouth of the well bore as the unit 3 is made to move therein.

The unit 3 comprises an elongated housing 10 to which the conductor cable 4 is attached so that the unit may be made to traverse the well bore and also that one or more of the conductors in the cable may comprise an electric measuring circuit. As illustrated, the conductor 11 is grounded to the housing 3 while the conductor 12 sealably passes through the cap 13 and, as illustrated in Fig. 1, terminates at its lower end in a variable resistor 14 which includes the sliding contact 15 attached to rod 16 passing through packing 17 in the conical partition 18 intermediate the ends of the housing. The lower end of the rod 16 is pivotally attached at 20 to the upper end of links 21 which are in turn pivotally connected to the upper ends of the arms 22. The arms 22 are pivoted at 23 to the housing 10. The lower ends 24 of the arms 22 are constantly urged outwardly into engagement with the walls of the well bore by means of a compression spring 25 surrounding the rod 16 below the packing 17.

72 The conductors 11 and 12 are connected to a source of electrical energy which is shown in Fig. 1 as a battery 26 in series with an indicating instrument 27 and also a recorder 28 so that either or both a visual indication or a record of the current flowing in the measuring circuit is provided. It seems apparent that the measurement thus obtained is indicative of the relative movement of the arms 22 and hence of the variations in the diameter of the bore 1.

The chamber within the housing 10 and above the partition 18 is partially filled with a suitable liquid 30, such as a light oil, the space 31 above such liquid serving as a displacement chamber so that the rod 16 may readily move as the diameter of the bore 1 varies.

As above explained, spontaneous earth potentials or the measurement of resistivity are affected by the electrical characteristics of the drilling fluid in the well bore and hence information of variations in the diameter of the bore and correlation of the electrical well log therewith are important in determining those earth formations which are potentially productive. Accordingly when a log of spontaneous earth potentials is to be obtained, a pair electrodes 32 comprise a part of the unit 3 and are connected by means of conductors 33 in cable 4 to the recorder 34 at the mouth of the well bore, so that an electrical log and the log provided by the recorder 28 are simultaneously produced, it being understood that such logs may be produced either separately as shown or in a single record as is well known in the art. It is also understood that in accordance with current practice the logs shall contain information as to the respective depths at which measurements are made. By means of the apparatus and the technique of the invention as thus far described there is provided desired information for additional steps to be taken in cementing a well casing within the bore 1 and perforating such casing to bring the well into production.

73 The construction shown in Fig. 2 is similar to that shown in Fig. 1 and like parts are identified by the same reference characters. It is to be noted also that the electrical logging equipment is omitted in this Figure. in this embodiment the conductor 12 is connected to a coil 40 which surrounds the rod 16 and which has its other terminal grounded at 41 to the housing 10. An alternating current is supplied to this circuit from a suitable source 42 and the instrument 43 indicates the current flowing in this circuit. A second coil 44 and a resistor 45 are carried by the rod 16 so that the coils 40 and 44 are held in inductive relation to each other, the coupling between the coils being varied as the rod 16 moves due to variations in the diameter of the well bore 1. Conductors 46 in the cable 4 are connected to the terminals of the resistor 45 and the coil 44 and to a double pole double throw switch 50 by means of which a connection may be made to the terminals of a resistor 51 or to an indicating or recording instrument 52.

When the switch 50 is closed to include the resistor 51 it seems apparent that the circuit thus formed will absorb energy which depends upon the coupling between the coils 40 and 44 and such condition will be reflected by the instrument 43 whereby such instrument will indicate the movements of the arms 22 as the unit 3 is made to traverse the well bore. If the switch 50 is thrown to the left so that the instrument 52 in included in the secondary electric circuit then the indication or record obtained by the instrument 52 will similarly indicate the movements of the arms 22, it being understood that under such circumstances the conditions in the primary electric circuit will be maintained constant.

74 The modified construction shown in Fig. 3 is the same as that already described except that the movements of the rod 16 are utilized to vary a capacitance 55 in the electric circuit which includes the source of alternating current 42 and the instrument 43. The variations in the capacitance 55 produce similar variations in the current flowing in the circuit and hence desired information is made available by observing or recording the variations of the reading of the instrument 43.

It seems apparent that by means of the construction and technique above described correlatable traces are obtainable whereby the volume of a bore hole is measured and hence information is made available of the amount of cement that will be necessary for cementing casing within such bore hole. At the same time the trace showing the variations in the diameter of the well bore constitutes a log showing the location, nature and extent of the respective formations. This trace is also correlatable with the electrical log of the bore to thereby provide additional and more accurate information as to the formation or formations at which perforation of the casing should be effected in order to bring the well into production.

The invention is also instrumental in avoiding a condition such as that shown in Fig. 4. As above pointed out, there is a particular tendency for hydraulic washing or jetting of the relatively soft formation such as the oil sand 56 whereby the cavity 2 is formed therein. The successively adjacent formations 61 and 62 being relatively harder are washed to a lesser extent and the bore in these formations is of smaller diameter, depending upon the hardness of these formations.

75 When a casing 57 is landed in the bore hole 1 and cementing is effected in accordance with usual procedure, a block of cement 60 is formed within the cavity 2. When it is desired to perforate the casing within the sand 56 a gun perforator 58 is lowered therein upon the cable 59.

Performing operations will, however, be unsuccessful since it is impossible for projectiles from the gun 58 to penetrate the cement 60 and enter the sand 56 to admit formation fluids to the interior of the casing 57. Accordingly a conclusion may, and frequently is, reached that the formation 56 is unproductive.

The present invention avoids this condition since the accurate information obtained through correlation enables resort to squeeze cementing above and below the cavity 2 and in this manner such cavity is not filled with cement. Hence when cementing is completed a perforator 58 may be lowered to the sand 56 and the well can thus be brought into production.

From the above description it may be seen that the invention provides novel method and means for surveying a well bore whereby difficulties heretofore experienced in bringing a well into production are minimized.

76 What is claimed is:

* * * *

80 IN TESTIMONY WHEREOF I hereunto affix my signature this 2nd day of Sept. A. D. 1941.

Alonzo L. Smith

* * * *

86 Commissioner of Patents,
Washington, D. C.

Dear Sirs:

Responsive to the action under "dual prosecution" dated April 10, 1942, in the above identified application, the applicant desires to amend as follows:

Please cancel Claim 5.

Claim 6, line 5, before "means" insert—a single—.

Remarks

The action accorded this application has pointed out that three inventions are disclosed but a requirement of division has not been made, apparently on the ground that Claims 1 to 4 are aggregational. It is understood that the action constitutes a rejection on this ground. On the strength of this ground of rejection, it is urged that an election has been made in accordance with the decision in re ex parte Mitchell, 1913 C. D. 233, and that inasmuch as certain claims are limited to electrical calipering, such claiming of the invention constitutes an election.

The Mitchell decision does not apply since, as will more fully appear, Claims 1 to 4 are not aggregational but are directed to a true combination of which the apparatus and technique of the remaining claims are subcombinations.

87 Furthermore, in the Mitchell case there was cancelled from the claims all reference to elements which were accused of rendering the claims aggregational. Such action was held to constitute an election.

In a consideration of the claims it was pointed out that Hardel shows that it has been proposed to caliper a well bore before cementing, while the patentee Ennis and the article "Hot Shots" shows that it has been proposed to run an electric log in an open hole before cementing and preliminary to a perforating operation for production. It is to be noted, however, that the term "aggregation" comprehends the grouping together of features that do not co-act to produce a unitary result. In the present instance such condition does not exist.

The present invention is concerned with obtaining accurate information of different factors which determine conditions at various levels within a well bore. In modern practice, well bores may penetrate to depths in excess of 10,000 feet. As indicated by the Examiner, it has been proposed to caliper a well bore before cementing and also to run an open hole log prior to cementing. In either of such cases it is important that insofar as possible accurate measurements of depth constitute a part of the information obtained. In working at various depths the weight of calipering and exploring equipment, the weight of cable used, the manner of operating equipment, well bore temperatures, etc. affect the accuracy of depth measurements. Hence, individual operations may indicate certain conditions at a given level, but due to the lack of precise coordination in measurements, such information is erroneous. In particular are the resulting errors important where thin earth formations are concerned in bringing about production of a well.

This applicant's method, as defined by Claim 1, is concerned with simultaneous measurements of electrical characteristics of a well fluid and the surrounding formations and of the variations in diameter of a well bore. These measurements cooperate to give accurate information inasmuch as they are simultaneously made, and hence
88 differential stretching of cables or variations in con-

ditions between runs into and from the well bore are avoided. Furthermore, the simultaneous measurements enable correction of the electrical log by way of compensation for the effect produced by variations at different levels in the quantity of drilling fluid proximate the penetrated formations. Hence it is submitted that the defined technique constitutes coacting operations and leads to a unitary result.

Claim 2 is similar to Claim 1 but includes the step of positioning the casing within the bore and cementing such casing above and below the potentially productive formation. Such operations permit the terminal step of perforating the casing at the formation with assurance that the perforating operation will be successful since the accumulation of a quantity of cement at that level is avoided.

Claim 3 is directed to the correlation of the electrical and caliphering log and the cementing of casing within the bore above and below the level determined by such correlation. As was pointed out in the specification, the potentially productive formations are usually relatively soft and porous and hence enlargements of the bore occur at such points. Continuous cementing at such areas may readily result in an impenetrable block of cement, as illustrated in Fig. 4 of the drawings, and at the point where perforations for production are desired. Cementing above and below the point to be perforated avoids this condition and hence there is co-action of the operative steps whereby a unitary and beneficial result accrues.

Claim 4 is believed allowable for the reasons set forth in connection with Claim 3 and for the additional reason that Claim 4 includes the limitation of perforating the casing within the intervening formation.

Claim 5 has been canceled.

89 Claim 6 as amended distinguishes from the reference in that the combination thereof involves a

single means attached to the inner ends of the arms so that movement thereof is indicative of average dimensions of the well bore. In the prior art structures each of the arms moves individually and mechanism is provided whereby the various movements may be interpreted as indicative of the average diameter of the well bore. The structure herein claimed is much simpler and hence obviates difficulties which may arise particularly at greater depths within the earth.

Claim 7 stands rejected on the ground that the structure is fully anticipated by Kinley 2,267,110. It is not seen as to how it can be said that the claimed construction is fully met or otherwise anticipated by the reference since the claim calls for a quantity of liquid in the chamber and a space thereabove to serve as a compression chamber and hence compensate for volumetric changes produced by the movement of the rod entering the chamber. It is believed that this feature of construction clearly distinguishes from the Kinley device in which there is provided a slidable piston to compensate for volumetric changes. The applicant's construction avoids the sliding contact that exists between the piston and surrounding walls in the Kinley structure. In view of this clear distinction from the prior art structure, it is submitted that in the absence of more pertinent art the claim should receive favorable reconsideration and allowance.

In view of the foregoing remarks directed to Claims 1 to 4, 6 and 7, it is believed that the species claims 8, 9, 10 and 11 are likewise allowable.

Claim 8 calls for a variable capacitance within the housing, a feature which is not to be found in any of the references.

In a similar manner, Claims 9, 10 and 11 directed
90 to the species of Fig. 2, call for induction means
within the housing and a source of alternating cur-

rent whereby variations in induction from movement of the rod within the housing provides an indication of the variations in diameter of the well bore.

A requirement of election as between Figs. 2 and 3 has been made. The applicant hereby elects to claim the species of Fig. 2 as represented by Claims 9, 10 and 11. As already pointed out, it is believed that generic claims are allowable in the application and hence that favorable reconsideration and allowance of the species claims should be accorded.

Action in accordance with the foregoing remarks is earnestly solicited.

Respectfully submitted,

LESTER B. CLARK
Counsel for Applicant.

* * * *

Applicant: Alonzo L. Smith
91 Ser. No. 411,761
Filed Sept. 20, 1941
For WELL SURVEYING DEVICE AND METHOD

Lester B. Clark
2200 Gulf Bldg.
Houston, Texas

U. S. PATENT OFFICE

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DEC 8 1942

MAILED

Amendment Oct. 6, 1942.

Additional References Made of Record:

Manning	2,029,380	Feb. 4, 1936	166/1AB
Baker	2,187,480	Jan. 16, 1940	166/1AB

Ennis	2,228,623	Jan. 14, 1941	255/108
Horner	2,296,852	Sept. 29, 1942	73/51
		Filed — Jan. 3, 1938	

"Baroid Service" Copyright 1940 Baroid Sales Div., National Lead Corp. Pages 5 and 15, copy in Div. 32, Class 255, Subclass 1.4

"Tomorrows Tools Today" Volume 5, No. 1, January 1939, pages 2 and 3, copy in Div. 32, Class 166, Subclass 1-A.

This is an action under "Dual Prosecution" by Division 32 on claims 2-4. Division 32 has general jurisdiction also.

Claim 5 is cancelled.

Claim 1 is rejected by Div. 48 in their letter.

Claims 5-11 are rejected by Div. 62 in their letter.

Claims 2-4 are rejected as aggregations. Applicant can argue about whether the calipering and electric logging form a combination. At least they are run on the same line so that the distance measurements are the same, and the chance of them being different on different trips is obviated. The same line could be used, and the two instruments could be the same weight, but even then there might be an error on different trips. Also, as the calipering relates to a correction of the electric log (page 2, second paragraph), there is ground for argument. But the setting of casing in the well, and cementing the casing and perforating it, has no combination with the type survey made. For example, in a new field a well is often core drilled from top to bottom. These cores are tested and from them a chart of the formation is made, all as
92 shown by Horner cited, Fig. 1. Still another method of testing is shown in the patent to Hayward cited, and Baroid Service cited, showing logging a well while

drilling by cuttings and fluid contents of cuttings. Now if there are three separate ways of obtaining a log of a well, namely (1) coring, (2) fluid sampling, and (3) electrically logging; then there is no combination between the method of taking the survey or log, and the setting, cementing, and gun perforating of a casing in a well. Regardless of how the log is obtained, the casing operations will be the same. Baker and Manning cited, show cementing above and below the producing formation.

If not an aggregation, then claims 2-4 are rejected on Ennis cited, showing the old combination of running an electrical log in an open hole (Fig. 6) and cementing in a casing (Fig. 4) and gun perforating (Figs. 4 and 7). The combination being old, the specific method of logging and calipering the open hole, and the specific method of setting, cementing and perforating the casing should be claimed per se in separate applications.

Claims 2-4 are also rejected on "Tomorrow's Tools Today" cited. On page 3, column 1, is a typical example. A rotary hole was drilled to 5, 208 feet. An electrolog was run in the open hole. Casing was run and cemented at 5,208 feet with 150 sacks (a small amount of cement). A dual seal cementer (page 2 explains what that is) cemented the upper stage at 3,725 with 175 sacks (a small amount of cement). The space in between 5,208 and 3,725 feet is cement free. (See section lines for water and cement in center figure on page 3, and remember the upper one was cemented last). Then the casing was perforated between 5,140 and 5,167 and 5,181 and 5,204, into the clear. No calipers are mentioned but as held by Div. 48 in rejecting claim 1 in their letter which rejection is made
93 a part of this rejection, in view of references applied therein, no invention would be involved in calipering the hole.

Claims 2-4 are rejected as drawn to an inoperative or incompletely disclosed device. Rule 50 requires applicant to show every feature claimed and he has not taught or shown how to cement above and below the shooting zone with no cement in the shooting zone.

The claims are all rejected.

MAR

FITH
Examiner.

* * * *

Applicant: Alonzo L. Smith
94 Lester B. Clark Ser. No. 411,761
2200 Gulf Building Filed Sept. 20, 1941
Houston, Texas For Well Surveying Device and Method

U. S. PATENT OFFICE
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This is an action under Dual Prosecution by Division 48 on claim 1. General jurisdiction is in Division 32.
New Reference

Bazzoni et al	2,167,630	Aug. 1, 1939	175/182

Claim 1 is rejected as an aggregation of independent steps. Measuring electrical characteristics has no cooperation with the claimed diameter step. In no way do the two steps combine, whether simultaneously or otherwise enacted.

Claim 1 is also rejected as clearly unpatentable over Bazzoni, of which see especially page 6, column 2, lines 15-23. Bazzoni discloses that electrical measuring apparatus and any well surveying apparatus may be lowered on the same cable and operated simultaneously. Such surveying apparatus obviously may be of any known type, for determining any desired physical characteristic such as direction, slope, diameter, temperature, pressure, etc. In view of the teaching by Hardel and Kinley of record that measuring the bore diameter variations is a step well known in well surveying, inclusion of the Kinley well-surveying device with any electrical measuring device like that of Cloud or Elliott of record or of Bazzoni, cited above, would be clearly unpatentable.

Otto B. Rolphe
Examiner

* * * *

Applicant: Alonzo L. Smith

95 Lester B. Clark Ser. No. 411,761
2200 Gulf Bldg., Filed September 20, 1941
Houston, Texas. For WELL SURVEYING DEVICE AND METHOD

U. S. PATENT OFFICE
R
DEC 8 1942
MAILED

This is an action under "Dual Prosecution" by Division 62 on Claims 5-11. General jurisdiction of this application is in Division 32.

Additional references made of record:—

Allen,	1,946,924	Feb. 13, 1934	33-148-H

Claim 6 is rejected as unpatentable over the references and for the reasons of record in view of Cox of record. The substitution of a single means for measuring the arm movement as shown in Cox for the plural means of Kinley would not involve invention.

Claim 7 is rejected as unpatentable over Kinley 2,267,110 of record since the volumetric compensating means of Kinley shown at the top of Fig. 4 is considered the equivalent of applicant's particularly if some of the liquid leaks out of chamber 22.

Claim 7 is further rejected on the ground of inoperativeness. Under the high pressure existing in a well the function of a seal not specifically disclosed in excluding the liquid from the inside of the casing would undoubtedly be destroyed. This is a well known fact in this art and is recognized by the Kinley structure which uses a chamber full of liquid and shiftable pressure responsive piston.

Claims 9 to 11 are rejected as unpatentable over the same Kinley reference in view of Allen. The substitution of relatively movable coils like those shown in Fig. 8, for the resistance measuring means of Kinley would require nothing more than mechanical skill.

96 Claim 8 is rejected on the ground of estoppel in view of applicant's election as expressed in his letter of October 6, 1942.

E. C. Pugh
Examiner

* * * *

97 Commissioner of Patents
Washington, D. C.

Dear Sir:

Responsive to the triple office rejections from Divisions 32, 48 and 62, the applicant desires to amend as follows:

Please rewrite claims 1 and 2 as claims 12 and 13.

12. The improvement in the art of investigating geological structures penetrated by a well bore which comprises the steps of simultaneously, measuring at various depths within fluid in the well bore the combined electrical

characteristics of the fluid and the surrounding formations, and measuring the variations in the diameter of the well bore at the various depths, and correlating the log reading obtained with the variations in diameter to determine the effect on the log readings of the variations in diameter as ascertained.

13. In the art of obtaining information for preparing
98 an earth bore for the production of petroleum the steps of, simultaneously electrically logging and measuring the variations in the diameter of the bore so as to obtain information of the electrical characteristics of the earth formations penetrated by the bore and to correct such information as it may be varied due to variation in the diameter of the bore, positioning a casing within the bore, introducing an amount of cement as indicated by the diameters measured which will effect the cementing of the casing above the area and below the area of productive formation as indicated by the log, and thereafter perforating the casing at said indicated formation.

Please cancel claims 3 and 4.

Please cancel claim 6.

Claim 7, line 6, cancel “measuring” and substitute—*indicating at the surface*—.

Line 7, after “bore” insert—*causing such movement*—, cancel “in” and substitute—*partially filling*—.

Line 8, cancel “ , there being” and substitute —*so as to provide*—.

Kindly add the following claims:

14. In the art of formulating an electrical log of an open well bore where the indications obtained are affected by diameter of the column of drilling mud or liquid in the well bore, the step of obtaining electrical logging readings, and simultaneously therewith obtaining a measurement of

the diameter of the bore at the elevation at which the readings are being taken, and correcting the reading obtained for variation thereof caused by variations in diameter of the column of liquid logged because of the variation in the diameter of the bore.

* * * *

16. A method of obtaining penetration of the
99 shot into a productive formation in a well bore
where the formation is washed out to a larger diameter than the bore during drilling by excluding such area from cementing which comprises calipering the well bore to ascertain the location, presence, diameter and extent of the washout, running a casing into the well, cementing the casing at spaced elevations above and below the washed out area so as to avoid filling the wash out with cement which might not be penetrated by the shot, and shooting the casing to form perforations therein at the non-cement area at the elevation of the washout.

17. A method of obtaining penetration of the shot into a productive formation in a well bore where the formation is washed out to a larger diameter than the bore during drilling by excluding such area from cementing which comprises calipering the well bore to ascertain the location pressures diameter and extent of the washout, running a casing into the well, cementing the casing at spaced elevations above and below the washed out area so as to avoid filling the wash out with cement which might not be penetrated by the shot, shooting the casing to form perforations therein at the non-cemented area at the elevation of the washout, and simultaneously on the same calipering device supporting an electrical logging mechanism to determine the nature and characteristics of the washed out formation.

18. A method of obtaining penetration of the
100 shot into a productive formation in a well bore

where the formation is washed out to a larger diameter than the bore during drilling by excluding such area from cementing which comprises calipering the well bore to ascertain the location, presence, diameter and extent of the washout, running a casing into the well, cementing the casing at spaced elevations above and below the washed out area so as to avoid filling the wash out with cement which might not be penetrated by the shot, shooting the casing to form perforations therein at the non-cemented area at the elevation of the washout, simultaneously on the same calipering device supporting an electrical logging mechanism to determine the nature and characteristics of the washed out formation, and correcting the determination of such logging mechanism for variation due to the presence of an additional volume of drilling mud or liquid in the washed out area.

REMARKS

Claim 1 has been rewritten as claim 12 to more particularly point out the correlation of the operations of the applicant. It is well understood that the volume of the fluid, or, as it might be stated, the diameter of the column of liquid in the well bore, has an affect upon the electrical log reading. As indicated by the examiner the cables or mechanism by which various devices are lowered into a well bore are subject to stretch and it is difficult to determine that a calipering operation conducted by the use of one cable and an electric logging operation conducted by another were obtaining readings at the same elevation which could be correlated. The applicant, therefore, has devised an arrangement where a single cable is used for manipulating both instruments so that the operator is assured that at any taken point electric log reading and the caliper reading are being simultaneously taken at that
point. The prior art does not suggest such an ar-
101 rangement and claim 1 has been amended to recite

such a procedure. The fact that more than one operation has been conducted for some other purpose in a well bore is not believed to be a suggestion for the examiner to reject the present claims. There is no combination suggested by the various references relied upon in rejecting claim 1 and it is thought that the claim should be allowed.

Claim 2 stands rejected as being an aggregation. This claim has also been amended materially to more particularly point out the applicant's invention and it is not now believed that the novel features of the claim are suggested by either Ennis or the publication of "Tomorrow's Tools Today." Neither of these references suggest the procedure called for by the claim and allowance thereof is believed to be in order.

Claim 2 is presented for reconsideration over the rejection that it is inoperative because the applicant has fully disclosed the structure and procedure recited in this claim. If the examiner desires an additional figure of drawing illustrating such procedure, such drawing will be furnished upon request of the examiner.

Claims 3, 4 and 6 have been cancelled because it is believed that the novel subject matter thereof is incorporated in the claims which are retained.

Claim 7 has been amended somewhat and is amended for reconsideration over Kinley because it is believed that the examiner is dealing in possibilities rather than in facts. It seems clear that the structure of claim 7 is not suggested in Kinley and reconsideration is asked.

As to the rejection of claim 7 on the ground that no specific type of seal is proposed, attention is directed to the fact that no seal is recited in the claim. Reconsideration is therefore believed to be in order.

Claims 9 to 11 inclusive are presented for recon-

102 sideration over Kinley in view of Allen. The applicant is unable to find any suggestion in Kinley for the substitution therein of the structure of Allen. It seems clear that the examiner has obtained a suggestion for this substitution not in Kinley or not in Allen, but in the applicant's disclosure. It is easy to see that only mechanical skill would be required after the applicant has suggested the combination, Kinley would have to be entirely rebuilt and operated on a different principle, the suggestions for which are found only in the present application. Reconsideration of these claims is therefore believed to be in order.

Claim 8 remains dormant in the application.

New claims 14 to 18 are presented for favorable consideration. These claims have been drawn with the references of record in view, they are believed to define invention over the prior art, and are directed to novel and operable combinations which are not suggested except by the applicant.

This amendment is intended to be responsive to all three of the office communications and is thought to place the application in condition for allowance.

Respectfully submitted,

LESTER B. CLARK
Counsel for the Applicant.

* * * *

	Applicant:	Alonzo L. Smith
103	Ser. No.	411,761
	Filed	September 20, 1941
Lester B. Clark	For	WELL SURVEYING
2200 Gulf Building		DEVICE AND
Houston, Texas		METHOD

U. S. PATENT OFFICE
R
JUN 17 1943
MAILED

Responsive to amendment of June 7, 1943:

The amendment of June 7, 1943 is not completely responsive to the last action. It fails to comply with Rule 68 and Order 2801 of February 20, 1923 in that it does not "show how the amendments avoid such references or objections."

In the last action by Division 32, claim 2 was rejected as being drawn to an aggregation. The action fully pointed out in detail exactly why the recited structure was considered to be an aggregation. Applicant has entirely neglected to point out how the rewritten claim avoids this ground of rejection and where there was any fallacy in the reasoning so carefully set forth in support of that ground of rejection.

Claim 2 was rejected further as being drawn to an old combination. Applicant has not pointed out any novelty of cooperation between the elements.

Applicant's bare statement that he has fully disclosed the structure and procedure is not sufficient to avoid the rejection on the ground of an incomplete disclosure. He should point out in detail how the claims are supported by the disclosure.

Applicant likewise should specifically point out the structure which he considers to distinguish claim 7 over the reference relied upon by Division 62.

104 Applicant has submitted new claims 14-18 without pointing out how they distinguish over the claims already in the case or how they avoid the grounds of rejection relied upon in treating the claims previously

of record. They should be compared with the most nearly similar claims previously of record and the manner in which they avoid the grounds of rejection of record against those claims should be pointed out.

In view of the fact that applicant's failure to respond completely within the statutory period apparently was due to inadvertence, he is given the period expiring on the date specified below, in order to avoid raising the question of abandonment. Circular of July 26, 1934.

TIME LIMIT IS JULY 12, 1943.

FITH

EXAMINER.

* * * *

U. S. PATENT OFFICE

105 JUN 28 1943

DIVISION XXXIII

Commissioner of Patents
Washington, D. C.

Dear Sir:

Responsive to the office communication of June 17, 1943, the applicant desires to amend as follows:

Kindly add the following claim:

19. In the art of preparing an earth bore for the production of petroleum the steps of, lowering an apparatus into the well bore which is capable of simultaneously electrically logging and measuring the variations in the diameter of the bore so as to obtain information of the electrical characteristics of the earth formations penetrated by the bore and correcting such logging information as it may be varied due to variation in the measured diameter of the bore.

REMARKS

It is respectfully asked that the amendment of June 7th be entered because counsel believes that it fully complies with Rule 68 as to an explanation asking reconsideration of the claims.

In the office communication of June 17, 1943, the examiner points out that in his opinion counsel has not answered the rejection on the ground of aggregation.

The first full paragraph on page 5 of the amendment of June 7th points out that the claim has been amended materially to more particularly point out the applicant's invention and goes on to state that the novel feat-
106 ures of the claim are not suggested by either Ennis (old combination) or the reference to the publication. Counsel considered these references and still contends that neither of the references suggest the procedure called for by the claim. This is certainly a sufficient answer and it is now incumbent on the examiner to point out in particular, as required by Rule 65 which specifically states that after the applicant has received his notice of rejection if "he shall persist in his claim with or without altering his specification, the application will be reexamined." The applicant certainly persisted in his presentation of the claim and asked reexamination thereof so that obviously counsel has complied with the rules. It is interesting to note, however, that Rule 65 makes the further provision that:

"If upon reexamination the claim shall be again rejected, the reasons therefor will be fully and precisely stated." Counsel is awaiting such statement on behalf of the examiner.

Only a casual inspection of the applicant's amendment shows that he presented claim 2 for reconsideration, not only over the rejection of aggregation, but for reconsideration over Ennis upon which the claim was rejected as being directed to an old combination, and then counsel presented claim 2 for reconsideration over the rejection that it was inoperative. Counsel does not understand just what the examiner means by inoperative unless the examiner is talking about some particular form of packing to provide a seal. The applicant is not trying to invent a packing, no packing is being claimed, and counsel is unable to see why the examiner is interested in this phase of the proceeding any more than he would be in an analysis of the steel being used or the composition, size, or dimensions of any of the other parts.

It is therefore asked for purposes of the record that the examiner desist from his objections to the disclosure insofar as it relates to any packing structure be-
107 cause such objection is irrelevant and immaterial insofar as patentability of the invention is concerned.

In further explanation of the applicant's argument in connection with aggregation it seems clear that by the examiner's statement by Div. 32, on page 1 thereof, in the last paragraph the examiner points out how he believes that the applicant should be entitled to argue that there is a combination between the electrical logging on the one hand and the calipering of the well on the other hand. The examiner's only objection is the inclusion of the setting of the casing in the well, the cementing and perforating of it. Of course, these last three features are well known in the art, but the applicant proceeds to accomplish them in a somewhat different manner and in a procedure incorporating the results obtained from logging and calipering. This is certainly a new assembly of data and operations put together for the first time by this applicant as is clearly apparent from the references of record; that these various steps recited in the claim constitute an aggregation is merely a conclusion on the part of the examiner. As examples to support his conclusion the examiner points out that a well may be cored from top to bottom. Suppose it is! The applicant is not claiming the coring of any well; so how can the examiner's example be in point.

The next example the examiner gives is the determination of the nature of the formation by detecting the cuttings and the contents thereof in accordance with Hayward. The applicant is not analyzing cuttings and counsel does not see how this example is in point. The examiner then goes on to point out that there are probably three ways of obtaining the log of the well and that therefore there can be no combination of any one of them with the cementing and perforating of the casing. In this it is believed that the examiner is clearly in error. The applicant's claims do not broadly recite the logging of the well, but
108 they recite the specific step of electrically logging. The applicant has therefore recited a different combination because the manner and amount of cement introduced and the place it will be positioned are controlled by the reports from the logging and calipering operations. The fact that they may be done at separate times has long been held not to destroy the combination so that as a matter of fact, the cementing, casing setting and perforaing will not "be the same" regardless of the type of log obtained, but they will only be governed by the information obtained by the applicant's electrical logging.

Thus we have a situation where the applicant claims that he has invented a new combination. The burden rests on the examiner of either allowing these claims drawn on this combination or placing of record an explanation as to why they do not constitute a combination. The only examples given by the examiner so far are not in point, the examiner has not found the combination in the prior art and counsel therefore respectfully submits the claims for reconsideration and a full and complete explanation on the part of the examiner which is backed up by more than his mere conclusion.

As to the rejection on the ground of old combination, the examiner relies upon Ennis and points out that Ennis has an electric log, then the cementing and then the perforating. The applicant is claiming something new and novel in addition to this combination of Ennis and adds thereto the step of calipering the open hole. If Ennis had a good combination between electric logging, cementing and perforating, then certainly the applicant has devised another new and different combination by adding the calipering thereto.

Counsel is well aware of the fact that the calipering operation is probably examinable in a different division in the Patent Office, but this is a problem of the Patent Office and not of the applicant.

109 Counsel believes that the foregoing arguments asking reconsideration of claim 2, which has now been rewritten as claim 13 are full and complete and the burden is clearly upon the examiner of first proving that the claims do constitute an aggregation of unrelated steps and second, of showing the applicant the combination thereof in some prior patent. The examiner has failed to place of record anything other than the barest of conclusions and counsel must insist that facts and circumstances be cited rather than conclusions.

Claim 7 was rejected as unpatentable over Kinley and as directed to an inoperative device. The claim was amended to bring out that the amount of liquid in the tool was such as to provide a space which would act as a compressing chamber to compensate for the volumetric changes produced by movement of the rod. The examiner is complaining that the applicant does not have sufficient packing to prevent leakage of his fluid from the container. Counsel would like to inquire as to what difference it makes whether or not the liquid does leak out because the more it leaks out, the greater will be the space left for

compression of that which remains due to operation of the tool so that certainly any leakage would not be an inoperative feature. In other words, the examiner objects to the applicant's construction because some of the liquid might leak out, then he turns right around and argues that the Kinley device would be like the applicant's "if" some of the liquid should leak out. Certainly the examiner is not very consistent in comparing his statements of criticism as to the present device and then he seeks to arrange the prior art so as to operate like the applicant's and to thereby place his blessing upon it so that it may be used as an anticipation. Certainly the examiner should be consistent and the record shows clearly that if the examiner believes that the applicant's construction is inoperative, that then he should point out the reasons why it is inoperative and counsel has offered to make such corrections as the examiner may deem necessary. Incidentally, counsel
would like to ask just how liquid in the applicant's
110 cylinder under, we will say, normal atmospheric
pressure can leak out of such cylinder when the tool
is introduced in the well bore with an excessive pressure outside. Thus, if there were any leakage at all, it would be from the outside into the cylinder and this leakage would occur until the pressures were balanced. Just what is inoperative about such a construction?

Kinley shows no expansion chamber space such as called for by claim 7 and as pointed out heretofore, the examiner is not relying upon the disclosure of the Kinley patent, but upon a fanciful operation thereof which exists only in the mind of the examiner.

The applicant submitted new claims 14 to 18 inclusive, claims 12 and 13 being claims 1 and 2 respectively in rewritten form, so that certainly no further explanation is needed as to them.

Claim 14 is directed to corrections to be applied to an electrical log due to the existence of a greater or lesser amount of drilling mud in the path of flow of the current. Certainly none of the claims in the application recite this general combination and an examination thereof on the merits is asked.

Claim 15 is directed to the method of simultaneously obtaining an electric log and the measuring of the caliper by the use of a single supporting mechanism. The examiner in Div. 38 on page 1 of his office letter of December 8th, admitted in substance that such a combination could be claimed and claim 15 is submitted for favorable consideration, being directed to somewhat the same subject matter as claim 14.

Claim 16 is directed to a manner of assuring that the perforating shots determine the amount of cement at any particular location which will be at that location enclosing the casing. This is a new combination of procedure steps disclosed by the applicant and to which the applicant is entitled to direct his claim, particularly when it ap-
111 pears of record that none of the prior patents even
remotely suggest such a combination of procedure. It is not incumbent upon the attorney to point out to the examiner which, if any, other claim in the application most closely approaches a new claim added thereto. If the examiner desires such information the original application and the newly presented claim are both before him.

Claims 17 and 18 are based upon claim 16, but add thereto the simultaneous feature of the calipering and the logging operations as to claim 17 and the correcting of the log due to the information obtained from the caliper as recited in claim 18.

The foregoing amendment and argument are believed to be fully responsive to the office communications of both December 8th and June 17th, and place the claims before the examiner for reconsideration.

New claim 19 has been drafted and is identical with the first eight lines of claim 13, and complies with the examiner's suggestion that claim 13 need not claim the cementing operations. This new claim is therefore presented for favorable consideration because the applicant does not find in the prior patents the structure called for. If the examiner is of the opinion that such structure is in the prior art, the next step in an orderly procedure would be for the examiner to consider the claim on its merits and advise the applicant of his decision.

Respectfully submitted,

Lester B. Clark
Counsel for the Applicant.

* * * *

Applicant: Alonzo L. Smith
Ser. No. 411,761
Filed Sept. 20, 1941
For WELL SURVEYING DEVICE AND METHOD

112 Lester B. Clark
2200 Gulf Building
Houston, Texas

Responsive to the amendments of June 7, 1943 and June 25, 1943.

This is an action by Division 32 on Claims 13 and 16-19, inclusive. The remaining claims are treated in the accompanying actions by Divisions 48 and 62 under "Dual Prosecution."

Claim 16, line 6, and in other similar claims "a spaced" should be at spaced.

Claim 13 is rejected as being functional, indefinite, and as being drawn to matter not disclosed. The cementing operation as recited in the last four lines is almost entirely functional. The only step positively recited at this point is introducing a measured amount of cement. The claim is indefinite in the sense that it fails to specify whether the cement is introduced over the producing formation or at points spaced above and below it. The claim is drawn to matter without adequate basis in the disclosure in that it implies measuring the volume of a portion of the bore and the introduction of a corresponding volume of cement. This operation is not found in the original specification.

Claims 16-19 are rejected and Claim 13 is further rejected as being drawn to an aggregation of unrelated features. The casing may be cemented in place when preceded by other logging methods than that recited or without any logging at all, and the specific logging method gives information useful for other purposes than as a
basis for the cementing method set forth. It is well
113 settled that such claims are defective as being drawn
to aggregations. In re Grapp 433 O. G. 5. Claim 19
brings out no relation whatever between the well logging and the positioning of a casing within the bore.

Claims 13 and 16-19 inclusive are additionally rejected as being drawn to an old combination in view of either "Tomorrow's Tools Today" or the patent to Ennis. The publication clearly discloses electric logging, positioning a casing, cementing the casing at spaced elevations above and below the producing formation, and gun perforating the casing at the producing horizon. This is the general organization of steps set forth and specific features of the electric logging, one of the elements, cannot add to the patentability of the combination. In re Plummer, 545 O. G. 14; in re Lincoln, 541 O. G. 668, Fig. 6 of the Ennis patent discloses the electric logging followed by positioning the casing as recited in Claim 19.

Claims 16-19 inclusive are still further rejected on "Tomorrow's Tools Today" in view of Bazzoni and Kinley to anticipate the logging and diameter measuring as applied in the action by Division 48.

Applicant may consider this rejection final, if he so desires.

Claims 1-6 inclusive has been cancelled.

Claims 7-11 are rejected in the accompanying action by Division 62.

Claims 12, 14 and 15 are rejected in the accompanying action by Division 48.

Claims 13 and 16-19 are rejected herein.

PAUL R. NEFF
Acting Examiner

	Applicant: Alonzo L. Smith
114 Lester B. Clark	Ser. No. 411,761
2200 Gulf Bldg.	Filed Sept. 20, 1941
Houston, Texas	For Well Surveying Device and Method

This is an action under Dual Prosecution by Division 48 on claims 12, 14, and 15. General jurisdiction of this case is in Division 32.

New references cited:

Lee	2,313,384	Mar. 9, 1943	175-182
Ennis	2,317,039	Apr. 20, 1943	175-182.1
Huber	2,072,950	Mar. 9, 1937	175-182

Claim 12 is rejected as unpatentable over Bazzoni et al in view of the known use of well diameter logs, exemplified by the Kinley references of record, on the basis previously explained in connection with claim 1.

Claim 12 is similarly rejected as unpatentable over Ennis of record, or Lee or Ennis cited above, in view of Kinley.

The taking of various logs by various instruments suspended together in a well is well known. Each of Lee, Bazzoni, and the Ennis references shows such combination logging. It is well recognized that well diameter influences the electrical log, and that electrical factors vary in accordance with well diameter. See for example Huber cited above, at page 4, column 1, lines 12-40.. In view of this common practice of taking different types of electrical and physical well logs simultaneously and correlating them in the usual way, it is not seen that taking and correlating the Kinley diameter log in the same way amounts to invention.

Claim 12 is also rejected as inaccurate in line 9, where "lob" should be *log.*

115 Claim 14 is also rejected as inaccurate. The "elevation of the readings" is the surface, in so far as any "readings" are present.

Claim 14 is also rejected as not supported by the disclosure. While the disclosure indicates that the diameter log may be used for correcting the electrical log, there is no disclosure of how this correction is applied.

Claim 14 is also rejected as unpatentable over Bazzoni, in view of Kinley and the well known inter-relationship between electrical properties and well diameter, discussed by Huber.

Claim 15 is rejected as unpatentable over Bazzoni et al, Lee, or either Ennis reference, in view of Kinley and the known relationship discussed by Huber, on the same basis as claims 12 and 14.

An issue has been reached as to claims 12, 14 and 15.

O. B. Roepke
Examiner

116 Lester B. Clark,
2200 Gulf Bldg.,
Houston, Texas.

Applicant: A. L. Smith
Ser. No. 411,761
Filed Sept. 20, 1941
For WELL SURVEYING
DEVICE AND METHOD

Responsive to the amendment June 25, 1943:

This is an action under "Dual Prosecution" by Division 62 on claims 7 to 11. General jurisdiction of this application is in Division 32.

Claims 7-11 do not avoid the grounds of rejection set forth in the Office action of December 8, 1942.

Applicant's arguments have been carefully considered but the Examiner remains of the opinion that the above claims are unpatentable over the references and for the reasons set forth in the above mentioned Office action.

Attention is further particularly called to the fact that it is the exclusion of liquid from the chamber 30 by the seal that is questioned in the last office action. The difficulties in excluding the well bore liquid from instrument chambers in this art is notorious and it is to overcome this difficulty that Kinley et al fill the chamber and provide the piston 61 to compensate for changes in volume. If it is admitted that there is no difficulty and no problem, then obviously Kinley et al does not need to fill the chamber and the Kinley device will operate in the same manner as applicant's with respect to compensation for change in volume.

Applicant admits that the instrument is intended to operate under high pressure, but overlooks the consequences of this chamber 30 filling under such circumstances, whereas it is apparent that there will be no provision for change in volume due to the movements of the measuring rod 16, or in other words, the rod will not be operative.

117 An issue has been reached as to claims 7 to 11.

E. C. Pugh
Examiner.

* * *

118 Commissioner of Patents
Washington, D. C.

Amendment For Purposes of Appeal

It is respectfully asked that the following amendments be entered for purposes of appeal in order to place the claims in somewhat better form and in accordance with the suggestions of the examiner in some instances.

Page 1, line 13, at the end of the line, change "of" to —through—.

Page 2, line 9, change "would" to —might—.

Line 10, cancel "it is impossible to" and substitute —the shots might not—.

Line 13, change "material" to —substantial—; after "cement" insert —rather than a thin wall thereof—.

Page 5, line 16, after "by the" insert —electrical characteristics of the—.

Claim 12, line 3, after "simultaneously" insert a —comma—.

Line 5, after "formation" insert a —comma—.

Line 6, after "and" insert —measuring—.

Line 9, correct the spelling of "log."

Claim 13, line 1, before "preparing" insert —obtaining information for the—.

Line 10, change "affect" to —effect—; after "above" insert —the area—.

Claim 14, line 4, cancel "simultaneously with the" and substitute —obtaining electrical—.

119 Line 5, cancel "operation" and substitute —readings, and simultaneously therewith—.

Line 6, cancel "of" and insert —at which—; after "readings insert —are being taken—.

Claims 16, 17 and 18, line 4 of each, after "drilling" insert —by excluding such area from cementing—.

Line 5 of each, before "diameter" insert —location, presence,—.

Line 6 of each, before "spaced" change "a" to —at—.

Line 10 of each, before "at" insert —at the non-cemented area—.

Claim 19, line 2, before "simultaneously" insert —lowering an apparatus into the well bore which is capable of—.

Line 5, cancel "to correct" and substitute —correcting such logging—.

Line 6, cancel "such."

Please rewrite line 7 to read as follows:
—measured diameter of the bore.—

Remarks

The specification and claims have been amended somewhat in order to place the application in condition for an appeal. Some of the corrections are to place the claims in proper form while others are made to more clearly distinguish the invention which is being claimed. An appeal is being filed simultaneously herewith and it is respectfully asked that this amendment be entered for purposes of appeal.

Respectfully submitted,

Lester B. Clark
Counsel for the Applicant

120 *Appeal to the Board of Appeals*

Comes now the applicant in the above entitled application and files this his appeal from the rejection of the primary examiner of Divisions 32, 48 and 62 under a triple prosecution. While the rejections have not been made final, each examiner indicated that an issue had been reached and the applicant has deemed it advisable to file an appeal. An amendment for purposes of appeal is attached hereto. The appeal fee of $15.00 is enclosed and the reasons for the appeal are as follows:

1.

The examiner erred in not allowing the claims in the application.

2.

The examiner erred in rejecting the claims in the application.

3.

The examiner of Div. 32 erred in rejecting claim 13 as functional and indefinite.

4.

The examiner of Div. 32 erred in rejecting claims 13 and 16 to 19 inclusive as being directed to an aggregation.

5.

The examiner of Div. 32 erred in rejecting claims
121 13 and 16 to 19 as being directed to an old combination.

6.

The examiner of Div. 32 erred in rejecting claims 13 and 16 to 19 in view of the publication "Tomorrow's Tools Today" when considered in view of Bazzoni and Kinley.

7.

The examiner of Div. 48 erred in rejecting claim 12 as unpatentable over Bazzoni when considered in view of Kinley.

8.

The examiner of Div. 48 erred in rejecting claim 12 as unpatentable over Ennis 2,228,623 or Lee, or Ennis 2,317,039 in view of Kinley when considered further in view of Huber.

9.

The examiner of Div. 48 erred in rejecting claim 14 as inaccurate and as not supported by the applicant's disclosure and further as unpatentable over Bazzoni in view of Kinley and further in view of Huber.

10.

The examiner of Div. 48 erred in rejecting claim 15 on Bazzoni or Lee or either of the Ennis references in view of Kinley and further in view of Huber.

11.

The examiner of Div. 62 erred in rejecting claims 7 to 11 inclusive as being anticipated by either Kinley, or Kinley in view of Allen, or because the structure of claim 7 is inoperative.

12.

All of the examiners erred in requiring an election of species.

13.

The examiner of Div. 62 erred in rejecting claim 8 on the ground of estoppel.

Respectfully submitted,

Lester B. Clark

Counsel for the Applicant.

* * * *

145 *Brief of the Applicant on Appeal*

This brief is filed at the present time in accordance with the extension of thirty days granted by the Board of Appeals in Paper No. 15.

The applicant has appealed from a final rejection of Claims 7 to 19 inclusive, the only claims remaining in this application, Claims 7 to 11 being directed to an instrumentality utilized in accordance with the invention, while

Claims 12 to 19 are directed to the applicant's novel method of investigating geological structures and effectively bringing into production, wells which pentrate such structures. Claim 15 is hereby withdrawn from the appeal and will be canceled.

The Invention

The Applicant's Problem:

The present invention resides in the field of production of oil and/or gas which are present within certain strata of the earth's crust after such strata have been penetrated by a well bore.

It is customary practice in the drilling of wells for oil, gas, and the like, to utilize the rotary method of drilling
wherein mud is circulated downwardly through a drill
stem and thence upwardly through the well bore to remove
cuttings, cool the bit, overcome formation pressures, and
prevent sticking of the drill pipe within the bore hole.
Some cutting action is effected by the circulated
146 fluid and this is particularly true at those horizons
which are of a porous nature, such as sands which
contain water, gas and/or oil and which are therefore potentially productive of these fluids.

An effort is made to observe every possible indication of the nature of formations penetrated by the well bore during drilling. However, in spite of equipment and methods heretofore devised, frequently potentially productive horizons are bypassed. Also productive strata may be relatively thin and may be closely displaced from other horizons, such as water bearing formations, from which production is not desired, and it is especially difficult to locate and selectively segregate such horizons.

In an effort to determine the location, nature, and extent of various horizons, particularly those which contain oil and/or gas, it is customary when drilling is completed to run a log by lowering instrumentalities into the well whereby variations in conditions such as natural earth potentials, resistivity, etc., may be determined. These logs are materially affected and may be rendered nugatory in any portion of the well bore where under-cutting has taken place. Hence, in some cases a potentially productive horizon is passed and abandonment of the well may be had because of adverse indications, or lack of information of the presence of a potentially productive stratum. The applicant has therefore sought method and apparatus whereby it is possible to more definitely locate these areas and to make necessary corrections for the erroneous indications resulting from the under-cutting.

147 After a survey has been completed and decision is made to test productivity at a given level or levels, it is customary to set casing within the hole and to secure such casing in place by pumping a cement slurry downwardly through the casing and thence upwardly about the outside of the casing whereby the well bore is completely encased. Thereafter a perforating tool is lowered within the casing and perforations are made within that area at which potential production is indicated. If, however, there has been a washout, or undercut, at the level at which production is contemplated, obviously a large amount of cement is concentrated at that point. For this reason, perforations may or may not extend through the casing and cement to the stratum which it is desired to tap. One phase of the problem of which solution is had by the applicant is that of providing such procedure and method that this perforating difficulty is likewise obviated and desired production also is effected.

The difficulties above indicated, and solved by the present invention, are accentuated when it is considered that in current practice it is not uncommon to extend drilling to a depth in excess of ten thousand feet. Such drilling is extremely expensive and it is therefore imperative, not only that potentially productive horizons be located, but that information obtained will permit the taking of such steps in bringing in the well that production from the potential horizons shall be assured.

The Solution of the Applicant's Problem:

In solving the problem above indicated, the applicant has developed instrumentalities and methods whereby it is possible to determine at the outset with greater accuracy the location and extent of strata of potential production. If a log, obtained in accordance with the invention is favorable, the solution also assures that the stratum in question is tapped for efficient production therefrom.

148 The solution of the problem obviates the condition illustrated in Fig. 4 of the drawings, wherein there is shown a productive stratum 56 penetrated by a bore hole 1 and in which under-cutting has taken place as indicated at 2. When a casing 57 is placed within such a bore hole and conventional cementing is resorted to, a mass of cement 60 is deposited within the cavity 2 and this condition may completely prevent, and will in any event, hamper perforating the casing 57 by means of a perforating gun 58 lowered therein.

An instrumentality for carrying out the invention is shown in Fig. 1, 2 and 3 of the drawings as comprising a unit 3, having a housing 10 upon which is mounted a pair of caliper arms 22 in such a way that movement of these arms will cause movement of the rod 16 axially of the housing. This rod extends through a packing 17 and into a body of oil 30 within the housing where the arm is so connected within an electrical circuit that current fluctuations through the conductor cable 4 leading to the surface at the mouth of the bore hole may be observed or recorded. It is to be noted that the chamber within the housing 10 is not entirely filled with a fluid 30, such as oil whereby there is provided a space 31 above the oil to serve as a compression chamber to compensate for the small displacement produced by movement of the rod 16 through the packing 17.

Inasmuch as difficulty is experienced, especially in deep well bores, as to that exact location of an observation, the invention also comprehends the provision of a pair of spaced electrodes 32 with the unit 3, the conductor cable 4 including conductors leading to and from these electrodes so that information concerning electrical conditions at the level of the bore hole measurements can be had through the recorder 34 at the mouth of the well bore. By means of this combination of instrumentalities, it is possible to determine with accuracy the conditions at any given level within the well bore.

149 The information thus obtained enables the determination and application of a correction factor to the electrical log which is obtained so that information is had as to whether or not the enlargement 2 is in a productive or non-productive horizon. If such horizon is in fact productive, the information obtained also indicates the steps to be taken whereby this horizon is brought into productivity. The method comprising one aspect of the invention and the operation of the instrumentalities as just described will more fully appear from a consideration of the claims and the grounds of rejection thereof

150 *The Claims and the Rejection Thereof*

Claims 7 to 11 inclusive:

In order to clearly indicate the invention as defined by these claims and to distinguish that invention from the prior art, reference is hereby made to claims 7, 8, and 9 specifically while claims 10 and 11 are discussed in relation to the first three claims.

Claim 7:

In a well surveying device the combination of,

(a) a housing having a chamber therein and adapted to be lowered into a well bore,

(b) a rod extending into said housing,
(c) means for moving said rod in accordance with variations in the diameter of the well bore,
(d) means operable by the movements of said rod for indicating at the surface the variations in the diameter of the well bore causing such movement,
(e) and a quantity of liquid partially filling said chamber so as to provide a space in the chamber above the liquid to serve as a compression chamber to compensate for volumetric changes produced by movement of the rod.

It is to be noted that this claim comprehends a combination of five elements, that element (b) calls for a single rod extending into the housing and element (e) calls for a quantity of liquid partially filling the chamber whereby a compression chamber or space is provided therein.

The Examiner has taken occasion to hold that this claim is fully anticipated by Kinley, No. 2,267,110, except for element (e), the Examiner then concluding that in as much as no special packing is shown or emphasized, there would be a mere matter of degree to partially fill the instrument container with liquid.

151 Referring to the Kinley patent, it is to be noted that four separate rods 42 are provided in the disclosed construction. For this reason there is relative large differential displacement resulting from movements of the rods in the patented construction and accordingly the patentee provides an equalized piston, the space beneath such piston being completely filled with an encased liquid. In the applicant's construction as defined on the other hand, there is provided a single rod extending into the housing and for this reason a very small compression chamber will satisfy requirements. It is therefore submitted that the patentee Kinley does not teach the defined combination and also that the distinction of the claimed

construction from that of the patentee is more than a mere matter of degree.

Claim 8:

In a well surveying device the combination of,

(a) a housing adapted to be lowered within a well,
(b) caliper arms pivotally attached to said housing,
(c) means normally urging said arms resiliently outwardly into engagement with the walls of the well,
(d) a variable capacitance within said housing,
(e) means operable by movements of said rod for varying said capacitance,
(f) and means at the mouth of the well bore and electrically connected to said capacitance for exhibiting the variations in the capacity thereof as a measure of the diameter of the well bore.

152 This claim is specific to the structure defined in Claim 7 in that the combination includes a variable capacitance in cooperation with the erstwhile recited means for providing at the mouth of the well bore an indication of diametral variations of the well bore. The Examiner has not seen fit to consider this combination inasmuch as he has rejected the claim only on the ground of estoppel in view of an election required in accordance with the provision of Rule 41. However, as above set forth, it is submitted that Claim 7, which is generic to the instant claim, is allowable and for this reason the rejection on the ground of estoppel cannot be sustained. The defined combination is definitely not shown in the prior art and it is therefore submitted that the structure as defined by claim 8 is likewise patentable.

Claim 9:

In a well surveying device,

(a) a housing adapted to be lowered into a well bore,
(b) a rod extending outwardly from within the housing,
(c) means for moving said rod in accordance with variations in the diameter of the well bore,

(d) a coil within the housing,
(e) means for supplying an alternating current to said coil,
(f) a second coil within said housing and movable by said rod,
(g) and means for measuring the variations in the inductive coupling between said coils as a measure of the variations in the diameter of the well bore.

153 This claim, as well as claims 10 and 11 are directed to the construction whereby magnetic coupling between coils within the housing is utilized to provide an indication of the movement of the caliper arms. The Examiner relies upon the patent to Allen on the ground that mechanical skill only would be necessary in providing a pair of coils such as shown in Fig. 8 of Allen in lieu of the resistance coupling means of Kinley. He does not, however, offer any suggestion as to how mechanical skill would be utilized in making necessary changes in the Kinley device. Attention is directed to the fact that in the Kinley construction there are four variable resistors 24, each of which has an actuating mechanism. Inquiry is made as to whether the mechanical skill suggested by the Examiner contemplates the provision of four separate sets of coils arranged in mutually inductive relation, or arranged in inductive relation as pairs only. Certainly, any such substitution would require that the Kinley device be reconstrutced in a manner not contemplated by the patentee Kinley.

It is also to be noted that the combination of the respective claims 9, 10, 11, and 12 set forth specific features in connection with this phase of the claimed construction. Claim 9 as above analyzed requires that one coil be mounted in the housing and supplied with an alternating current and that the second coil shall be movable by the rod, element (b).

Claim 10 recites that the second coil is mounted on the rod for movement in inductive relation to the first mentioned coil while claim 11 recites that the coils comprise a pair of which one is fixed and the other is "movable by said rod".

For the reasons above set forth, it is submitted that the Examiner has not shown a structure such as that defined by any of Claims 7 to 11 inclusive and that he is therefore in error in rejecting the claims on the respective grounds above indicated.

154 Method Claims 12 to 14, and 16 to 19:

These claims are directed to the applicant's disclosure of a method of obtaining improved information concerning the location and extent of potentially productive horizons and also utilizing such information in a manner to bring a well to the productive stage with certainty that perforating has tapped the productive horizon. This is brought about by logging the well in a manner that the configuration of the bore hole and electrical conditions in and about the bore hole, are determined with certainty for each successive portion thereof. The method comprehends the utilization of this information in a manner that desired horizons are segregated, but that such segregation does not interfere with the perforating of the tube positioned within the well. Reference is now made to certain of the claims specifically as indicative of the manner in which the claimed technique avoids the prior art and provides desired results as indicated by the problem confronting the applicant.

Claim 12.

> The improvement in the art of investigating geological structures penetrated by a well bore which comprises the steps of
>
> (a) simultaneously, measuring at various depths within fluid in the well bore the combined electrical char-

acteristics of the fluid and the surrounding formations,

(b) and measuring the variations in the diameter of the well bore at the various depths,

(c) and correlating the log reading obtained with the variations in diameter to determine the effect on the log readings of the variations in diameter as ascertained.

This claim comprises a combination of three steps of which the first two are distinctly correlated in that they are taken simultaneously. As already indicated herein, in modern drilling, bore holes in excess of ten thousand feet are not uncommon. If, therefore, measurements are separately taken in such bore holes, it is not at all certain that depth indications of successive measurements will be correlated, whereas in accordance with the present invention such correlation is assured.

155 The combination of steps further includes, (c), the utilization of the log reading in a manner to compensate for the effects produced by the volume of liquid within bore enlargements thereby completing the information necessary to determine whether or not production shall be attempted at a given stratum. As is more fully apparent, not only does this information indicate the location and extent of potentially productive horizons, but it also serves the additional purpose of dictating those areas which are to be distinctly segregated. This segregation is likewise of importance as it is well known that failure to segregate a water producing stratum from an oil or gas stratum requires re-working of the well unless inefficient production is to be tolerated.

The Examiner relies upon Bazzoni, p. 6, Column 2, Lines 15-23 which incidentally suggests that, in addition to making a high frequency impedance test within a bore hole, inclinometer means may be lowered with the principal instrument. This bore suggestion certainly offers no teaching that would be helpful in solving the applicant's problem.

Ennis (a) is referred to as showing "combinations of means for placing a marker, for perforating a casing and for locating a marker or an indentifiable stratum by means of an electrical log recording device." As a matter of fact, this patentee seeks to log a well and, during logging, to position markers within the well so that the marked levels can be subsequently located by suitable detector means and used as "bench marks" for further operations.

Ennis (b), relied upon, seeks to locate the point of entry of water into a well and to this end he lowers a container with a quantity of conditioning chemical to be distributed at various points, the device including means for thereafter testing the liquids at different levels to determine fluid movements and/or diffusion whereby the point of entry of fluid to the well can be determine.

156 These Ennis patents are not even pertinent to the present invention. They offer no suggestion of help in solving the applicant's problem. In fact the only feature they have in common with the present invention is that they are concerned with operations in a well bore.

The patentee Lee logs a well bore and recognizes that the log may be affected by temperature changes from circulating mud which is considerably lower in temperature than the formations about the bore. He accordingly makes periodic temperature measurements which are utilized to determine terrestial temperatures and hence make corrections to the log.

The Examiner admits that the references do not teach nor suggest the technique of the claims. In retrospect the rejections merely hold that it is not new to investigate a plurality of values simultaneously. He thence holds forthwith that since Kinley (a) and (b) teach diametral logging of wells, there is no invention in simultaneously, and at the same level, obtaining an electrical log and a diametral log whereby these values at any level are known with a certainty and are used, as does the patentee Lee, to correct otherwise erroneous logging information. This is correlated information which not only rectified the log but also dictates as to those horizons which are potentially productive and also as to the manner in which cementing and perforating of tubing are to be carried out so that such horizons are tapped.

The foregoing remarks directed to Claim 12 are also applicable to Claims 14, and 19 which admittedly recite the same steps in slightly different terminology.

Claims 12, 14 and 19 also stand rejected as unsupported by the disclosure in that the disclosure does not detail the manner of determining the correction to be used, once the electrical log and diameter log are available. This is believed an erroneous rejection as it is well known that correction and interpretation of logging graphs are an important element in providing complete information from well measurements whereby further steps may be taken to bring about production. The correction required depends of course upon the nature of the drilling fluid in the bore and, in particular, the extent of diameter variations and
157 will be derived from such factors in a given instance.

An analysis of Claims 13 and 16 is as follows:

Claim 13.

In the art of obtaining information for the preparing an earth bore for the production of petroleum the steps of,

(a) simultaneously electrically logging and measuring the variations in the diameter of the bore so as to obtain information of the electrical characteristics of the earth formations penetrated by the bore and to correct such information as it may be varied due to variation in the diameter of the bore,

(b) positioning a casing within the bore,

(c) introducing an amount of cement as indicated by the diameters measured which will effect the cementing of the casing above the area and below the area of productive formation as indicated by the log, and thereafter perforating the casing at said indicated formation.

Claim 16.

A method of obtaining penetration of the shot into a productive formation in a well bore where the formation is washed out to a larger diameter than the bore during drilling by excluding such area from cementing which comprises

(a) calipering the well bore to ascertain the location, presence, diameter and extent of the washout,

(b) running a casing into the well,

(c) cementing the casing at spaced elevations above and below the washed out area so as to avoid filling the washout with cement which might not be penetrated by the shot,

(d) and shooting the casing to form perforations therein at the non-cemented area at the elevation of the washout.

It is to be noted that the first of these claims comprises a method of three steps, which are such as to assure that the proper amount of cement is supplied to seal off those formations which are adjacent to the one from which production is desired. Furthermore, the procedure is such as to obviate the possibility of producing a slug or mass of cement within the productive zone in the manner indicated in Fig. 4 of the drawings.

158 Hence the claimed method accomplishes two things, namely it assures an effective perforating

operation, and it also assures that adjacent formations will be sealed off. These adjacent formations may be water bearing or may include high pressure gas instead of oil of which production is sought. In either event it is imperative that the producing zone be segregated in order that desired and efficient production may be had. The Examiner relies upon the publication "Tomorrow's Tools Today", as disclosing the method claimed. In such reliance he points out that a side tracked well was cemented at the 3,725 foot level, and also at the 5,208 foot level with small quantities of cement. Thereafter, perforations were made in the casing at two levels which respectively embrased distances of 27 feet and 23 feet.

In accordance with the publication an electrical log was run. However, no information was had as to the diametral variations of the well bore, nor does it appear in that particular instance that undesirable strata existed within the 1,500 foot span between the points at which cementing was effected.

In any event, it is obvious that the brief and sketchy disclosure of the publication certainly does not teach the combination of steps called for by the claims here in question. It is therefore submitted that the publication falls short of constituting an anticipation of the above claims, and, as well, Claims 17 and 18, to be further considered.

Claim 16, above analyzed, is directed to a method of obtaining the penetration of shot into a formation where such formation has been washed to a larger diameter during drilling. This method comprises a combination of four steps including that of shooting the casing at the non-cemented area which has been segregated in the manner as above indicated in the erstwhile recited steps, (a), (b), and (c). As above indicated it is quite apparent that the publication relied upon does not teach this method, nor one which will assure efficient production from a selected horizon.

Claim 17 is similar to Claim 16, but includes the
159 step of electrically logging simultaneous with the
calipering operation, whereby the identity of the
horizon is established and, as well, effective perforating
is assured when cementing is carried out.

Claim 18 is still further limited by the inclusion of the step of correcting the electrical log from information obtained of variations in the diameter of the well bore. These more limited claims likewise clearly distinguish from the publication relied upon by the Examiner.

The patent to Ennis, 2,228,623, is referred to as cumulative, and is relied upon as disclosing the running of an electrical log, cementing a casing, and thereafter perforating such casing. Admittedly, this reference does not disclose the claimed method, nor one that will accomplish the results obtained by the applicant's method as above set forth.

The Kinley patents, it is true, propose calipering a well bore to provide information of variations in the diameter of the bore. These patents likewise do not offer any suggestion of a procedure which includes a log of diameters whereby results obtained by the present method are accomplished.

Claim 13 has been rejected by the Examiner as indefinite in its recitation of ''introducing an amount of cement as indicated by the diameters measured which will effect the cementing of the casing above the area and below the area of productive formation as indicated by the log''. It is suggested that this merely directs the operator in some manner to introduce a quantity of cement into the well, and that the claim is indefinite in that it does not recite how this is to be done. The applicant does not maintain that it is new to cement at different levels or that he has developed a novel cementing method per se. He does submit, however, that there is invention in the method whereby the levels at which cementing is to be effected are determined with a certainty, and in a manner that the desired volume of cement can be readily ascertained so that undesired strata will be sealed off, and yet production from the selected stratum will not be hindered. It is therefore submitted, that the portion of the claim to which objection has been made, adequately defines this phase of the method.

Claims 13, 16, 17, and 18 have also been rejected
160 as being drawn to an aggregation of unrelated features. It appears that the applicant's only reason for holding that the claims are drawn to aggregations, is the inclusion of the setting of the casing in the well and the cementing and perforating of such casing. While it is true these features are known in the art, yet, as is apparent from an analysis of the claims, the applicant proceeds to accomplish these steps in a different manner whereby unitary results are obtained from the correlated use of the respective steps. This is certainly a new combination of steps which cooperate to produce a unitary result, and it is understood that a combination of operations which cooperate in this manner to produce a novel result, or to more efficiently produce a result heretofore obtained, is new and patentable, and is not subject to the objection that it constitutes an aggration.

In the decisions relied upon by the Examiner, it was found that there was in fact no cooperation of the respective elements of the claims in question. In the present case, however, it seems apparent that there is in fact a definite cooperation of the steps set forth in the claims, whereby a new and improved result is obtained.

More pertinent to the present situation is the recent decision of the Court of Customs and Patent Appeals in the decision In re Smith, 49 U.S.P.Q. 90. In that case there was a question of the patentability of a claim for a method of bringing in a well, a method which is quite akin to the one here in question. The Court held that the references did not teach or suggest, either the appellant's claimed combination or method which solved a problem theretofore existing. Such being the case the Court allowed the claims.

Also pertinent to the instant case is the following observation made by the Court in the Smith case:

"It seems to us that if obviousness can be said to be derived from the references, on the record here it must necessarily (4) spring from knowledge derived from appellants structure, and we think the following statement made by the court in the case of In re Deakins, 25 C.C.P.A. (Patents) 1153, 96 F. 2d 845 (37 USPQ 693), is applicable:

161 We have carefully examined the references for a suggestion of appellant's combination and the new and useful results obtained thereby, but have found none. Of course, if the references are examined in the light of appellant's disclosure, the solution of the problem confronting appellant seems simple. A problem solved is no longer a problem, and one is prone to overlook the fact that it ever existed."

162 The Examiner has also suggested that in event the claims are proper combination claims, then they are rejectable on the ground that they are drawn to an exhausted combination in view of either "Tomorrow's Tools Today" or the patent to Ennis. This ground of rejection is likewise untenable since, as above pointed out, both of these references fail to show the combination whereby such combination can be construed as exhausted. It is true that the references show a somewhat similar pattern, but they do not show the defined combination of steps whereby results are obtained that were not obtained in accordance with the teachings of the respective references.

Conclusions

1. Claim 7 aptly defines the mechanism embodying the invention which comprehends the use of a single actuating rod and a quantity of liquid providing a pressure chamber to permit necessary movement of the rod. The combination which includes these features is not to be found in Kinley 2,267,110, nor are the differences of the claim structure from the Kinley disclosure a mere matter of degree.

2. Claim 7 is generic to claim 8, and the requirement of an election and subsequent rejection on the ground of estoppel are in error. The application should be remanded for a consideration of Claim 8 on its merits.

3. Claims 7 to 11 are not anticipated by either Kinley et al 2,267,110, nor by the Kinley et al patent in view of Lee.

4. While Bazzoni et al, Ennis (a) and (b), and Lee disclose features in connection with the logging of well bores, yet such patentees, or any proper combination thereof, do not disclose the method defined by Claims 12, 14, and 19. Furthermore, these claims are adequately supported by the disclosure.

5. Claims 13, 16, 17, and 18 are directed to a novel method of locating productive strata and bringing such strata into production through the combination of steps set forth by these claims. "Tomorrow's Tools Today" is wholly inadequate to teach the claimed method. Accumulative disclosure as presented by Ennis, Kinley, and
Kinley et al, likewise do not teach the applicant's
163 novel combination of steps whereby new and useful
results are attained.

6. Inasmuch as the combination of steps set forth by the respective Claims 13, 16, 17, and 18 cooperate to give light to new and useful results, such claims are erroneously rejected as aggregational.

7. None of the references shows the combination of any of Claims 13, 16, 17, and 18, and hence the claimed combination is not an exhausted combination.

8. The Examiner erred in rejecting Claims 7 to 14, and 16 to 19.

9. The Examiner erred in not allowing the above indicated claims.

In accordance with the foregoing, it is submitted that the claims under rejection define an invention possessing requisite novelty and utility, and that the decision of the Examiner should therefore be reversed.

Respectfully submitted,

LESTER B. CLARK,
Counsel for the applicant.

* * * *

169 *Request for Re-Consideration*

Comes now the applicant and respectfully asks reconsideration of the decision dated March 22, 1945. This request is particularly directed to Claims 12, 14 and 19 treated by Division 48, and Claims 13, 16, 17 and 18 treated by Division 32.

Counsel has reviewed the decision of the Board of Appeals and believes that in some manner the Board arrived at conclusions which do not appear to be justified by the record. For instance: on page 3 of the Decision, the last full paragraph, the Board has stated: "We understand that applicant does not claim to be the first to have correlated electrical log readings and bore diameter readings made at the same places in the bore at different times."

The art shows that the Kinley patents teach the procedure for measuring the bore diameter as a separate and independent operation as concerned with any other survey or investigative procedure. On the other hand, other prior patents show the idea of making an electrical survey or log of the well.

The problem which the applicant is attempting to solve is that of insuring that he is able to determine the diameter of the well bore simultaneously with any variations which may occur in connection with an electrical log survey.

Attention is directed to the patent of Ennis' 2228623,
page 2, column 2, lines 54 to 75, and page 3, col-
170 umn 1 through line 35, and in the middle of the sec-
ond column of page 2 Ennis indicates that there may be a variation of as much as 2⅛ feet in the elevation of different readings taken at different times. The applicant seeks to avoid this undeterminable error or variation by arranging this apparatus so that the diameter measuring equipment and the electrical log equipment are disposed at the same elevation, as clearly seen in Fig. 1 of the applicant's drawing. In this manner the log showing the variations in the diameter of the well bore will be recorded side by side with the electrical logging record.

The essential novelty act and conception of the applicant was not so much the correlating of the two logs as it was the simultaneous taking of the two readings by manipulation of a single piece of equipment, so that the applicant would be aware of the fact that his readings as to diameter and as to electrical characteristics were taking at exactly the same elevation.

Counsel agrees with the Board of Appeals in stating that the act of correlating readings would be the same whether they were taken simultaneously or not. Of course, a variable and undetermined correction would have to be made if the logs were taken separately and an effort made to compensate for variation in the stretch or length of the cable, or other equipment being used. It has been impossible, in the past, to estimate such variations accurately. The applicant appears to be the first to have lowered an electrical well survey instrument and a well calipering together.

The rejection of the primary Examiner, which has been sustained by the Board of Appeals, deals only in generalities rather than getting down to the facts in the case. The Honorable Board held that they saw no patentable significance in this correlating step and, therefore, sustained the primary Examiner. It is believed that the
171 Board of Appeals did not quite understand that
the applicant is not predicating his novelty upon the correlating step, but is predicating it upon the fact he obtains simultaneous readings, and that these simultaneously taken readings permit him to obtain an accurate correlation. The correlation is thus secondary to the simultaneous act of taking the readings. With this in mind, attention is respectfully directed to the prior art referred to by the examiner in Division 48, as applied to these Claims 2, 14 and 19.

The examiner has called attention to four patents, the first of which is the patent of Bazzani, who discloses the idea of measuring the inclination of the hole in the same operation with an electric log. In this instance Bazzani does not obtain any information which permits him to take advantage of one operation due to having performed the other operation simultaneously therewith. Thus counsel can ask what the inclination of the bore has to do with the electrical logging of it? One does not change the other or give any assistance in the analysis or interpretation of the other.

As distinguished from this, the applicant has definitely pointed out in his description that the electrical characteristics of the drilling mud, which fills the hole, affects the reading of the electrical log. The electric log must be corrected for the thickness of the layer of drilling mud filling the diameter of the well bore, because this drilling mud changes the resistivity reading, so that it is of substantial advantage to the operator to know that when he attempts to interpret the electrical log, that he has before him the exact diameter of the well bore at that exact elevation of the electrical log which he is attempting to interpret, that he does not have a variation anywhere 1 to 21 feet at which he must guess at the diameter of the well bore.

It seems so clear to counsel that there is a very
172 substantial advantage obtained by knowing unquestionably that at any particular elevation of the electrical log that the diameter log, which he has alongside of the electrical log, compares exactly as to elevation. It simplifies his problem of interpretation and correlation tremendously; it removes the doubt and uncertainty of determining whether or not the two readings at any particular point, are in exact alignment as to elevation. If the electrical log reading is taken in one operation and the diameter measuring performed as another and separate operation, the operator has absolutely no assurance whatsoever that his two records are in alignment as to elevation. He can guess at the time, of course, but it seems that the applicant is the first to take the "guessing" out of the interpretation; that he has accomplished this advantage by combining the well surveying and the diameter measuring instrument into a single unit. Attention is directed to the fact that the claims of the applicant call for an operation such as that just described.

Counsel would like to inquire as to when and how the Bazzani patent can serve as an anticipation of such method as has been described above?

The first Ennis' patent 623 recognized the difficulty which the applicant is seeking to correct. Ennis attempted to correct it in a different manner, namely: by making his surveying and determining the elevation of a certain marker and in attempting to get back into the hole after a certain operation and log such marker with a view of eliminating error. Such a procedure is not the solution conceived by the applicant. Because Ennis attempted to solve the applicant's problem in a different manner by a different procedure is no reason for rejecting the claims of the applicant.

The second Ennis' patent 039 makes test of the well fluid and formation fluid. Just how does this touch the applicant's invention? Ennis is attempting to solve 173 another and a different problem.

The patent to Huber confirms the applicant's disclosure to the effect that a variation in the diameter of the well bore and, consequently, the diameter of the drilling mud has a bearing upon the electrical log reading. Huber does not solve the problem. He recognizes the difficulty but fails of a solution.

The Board of Appeals have reversed the Examiner as to his rejection affecting claims 12, 14, 19, unsupported by the disclosure. Reconsideration of these claims for reasons argued above is respectfully asked.

Claims 13, 16, 17 and 18 treated by Division 32 were allowed to be proper claims by Board of Appeals when they reversed the Examiner on his rejection that these claims were functional or indefinite or were directed to aggregations, that these stand in the case as proper claims rejected solely on the art cited against them. This art teaches the idea of cementing the bottom of a well casing in position and then stage cementing another area of the well bore spaced a distance thereabove. But contrary to the interpretation of each the Examiner and the Board of Appeals, this prior publication does not teach the idea of taking simultaneous readings of the electrical characteristics of the well and measuring the bore diameter simultaneously so that at any particular elevation the cement may be omitted. For instance, in the publication referred to the Typical Example shows conclusively that the applicant's invention is not anticipated, because the well was shown as 5208 feet in depth, and that 150 sacks of cement were used. This amount of cement would have formed a sheath around the casing for a substantial distance upwardly in the bore. The example then states that the operator perforated the casing between the elevation of 5181 feet and 5204 feet, thus the lower perforations were only 4 feet above the bottom of the casing.

174 Both the examiner and the Board of Appeals seem to have interpreted this publication as meaning that the elevation where production was to be obtained was not cemented. Certainly 150 sacks of cement in a small annulus, whose total thickness included each side, was only 1⅛″ thick, would cause cement to rise a very great distance. In other words: If the hole were 7¾″ in diameter and the casing was 6⅝″, the area on each side which is to be filled with cement would be only 9/16″; or there would be a cylinder of cement whose wall was only 9/16″ thick and whose length would be sufficient to use up a volume, 150 sacks of cement, thus the cement would move maybe several hundred feet up the casing.

What counsel is trying to say is, that taking the Typical Example of the publication at its face value, counsel cannot see how it suggests the applicant's inventive idea? The fact that 175 sacks of cement were put in a hole some 1500 feet higher up does not affect the applicant's problem at all. The applicant is merely trying to keep the cement away from an area just shown to be productive by simultaneous electric log and the diameter reading. If this publication teaches this idea, counsel is unable to understand it, and it is believed that in reconsidering this angle of the case the Board of Appeals should either reverse the previous holding or explain fully, for the record, just how the publication serves as an anticipation.

The Kinley and Ennis patents thus fail to teach the simultaneous reading and, therefore, must fail as anticipations.

It is respectfully asked that favorable reconsideration be given to these two groups of claims mentioned above.

Respectfully submitted,

Lester B. Clark,
Counsel for the Applicant.

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175 IN THE UNITED STATES PATENT OFFICE

BEFORE THE BOARD OF APPEALS

RE: APPLICATION OF
ALONZO L. SMITH

SERIAL NO. 411,761

FILED: SEPTEMBER 20, 1941

FOR: WELL SURVEYING DEVICE AND METHOD
BEFORE THE BOARD OF APPEALS

APPEAL NO. 924

BOARD OF APPEALS

APR. 25, 1945

U. S. PATENT OFFICE

Supplemental Statement Re-Request for Reconsideration

At an oral conference very kindly granted by Assistant Commissioner Van Arsdale on Friday, April 20th, Counsel for the applicant reviewed the advantages of the invention involved in the claims on appeal and explained the distinctions in the applicant's invention as compared generally with the prior art.

While the request for reconsideration was directed as to the three claims being treated by Division 48 and the four claims being treated by Division 32, Counsel for the applicant indicated to the Commissioner that the applicant would be satisfied if he could obtain the allowance of claim 13 being prosecuted before Division 32 and claim 14 being prosecuted before Division 48.

It was pointed out that these two claims were representative of the two important phases of the invention and particularly claim 14.

The applicant would be willing to cancel the remaining claims in the case except allowed claim 7, if it is possible to obtain the allowance of claims 13 and 14.

This statement makes of record the substance of the oral conference.

Respectfully submitted,

Lester B. Clark,
Counsel for the applicant.

* * * *

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[Items A, B, C, D, E, F, G, H, I, I', appear on page 123 of this volume.]

J—Examiner's Statement (Div. 62), on Claims 7 to 11, inclusive.

K—Examiner's Statement (Div. 48), on Claims 12, 14, 15 and 19.

L—Examiner's Statement (Div. 32), on Claims 13, 16, 17 and 18.

M—Decision of the Board of Appeals.

N—Decision of the Board of Appeals on Request for Reconsideration.

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DEPARTMENT OF COMMERCE

272 UNITED STATES PATENT OFFICE

Richmond, Virginia

In re application,
Alonzo L. Smith,
Serial No. 411,761
Filed: Sept. 20, 1941
For: WELL SURVEYING DEVICE
AND METHOD

On Appeal
to the
Board of Appeals

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Paper No. 12a

Examiner's Statement

This is an action under dual prosecution by Division 62 on claims 7-11. General jurisdiction of this application is in Division 32.

Applicant appeals from a final rejection of claims 7-11 drawn to a caliper and copied below:

Claim 7. In a well surveying device the combination of, a housing having a chamber therein and adapted to be lowered into a well bore, a rod extending into said housing, means for moving said rod in accordance with variations in the diameter of the well bore, means operable by the movements of said rod for indicating at the surface the variations in the diameter of the well bore causing such movement, and a quantity of liquid partially filling said chamber so as to provide a space in the chamber above the liquid to serve as a compression chamber to compensate for volumetric changes by movement of the rod.

Claim 8. In a well surveying device the combination of a housing adapted to be lowered within a well, caliper arms pivotally attached to said housing, means normally urging said arms resiliently outwardly into engagement with the walls of the well, a variable capacitance within said housing, means operable by movements of said rod for varying said capacitance, and means at the mouth of the well bore and electrically connected to said capacitance for exhibiting the variations in the capacity thereof as a measure of the diameter of the well bore.

Claim 9. In a well surveying device, a housing adapted to be lowered into a well bore, a rod extending outwardly from within the housing, means for moving said rod in
accordance with variations in the diameter of the
273 well bore, a coil within the housing, means for sup-
plying an alternating current to said coil, a second coil within said housing and movable by said rod, and means for measuring the variations in the inductive coupling between said coils as a measure of the variations in the diameter of the well bore.

Claim 10. In a well surveying device, a housing adapted to be lowered into a well bore, caliper arms pivotally attached to said housing and movable outwardly into engagement with the walls of the bore, a rod in said housing attached to and movable by said rods, a coil, a source of alternating current connected thereto, a second coil mounted on said rod and movable inductively relative to the first mentioned coil, and means for measuring the inductive coupling between said coils.

Claim 11. In a well surveying device, a housing adapted to be lowered into a well bore, caliper arms pivotally attached to said housing and movable outwardly into engagement with the walls of the bore, a rod in said housing attached to and movable by said rods, a pair of coils in said housing, one of said coils being fixed and the other being movable by said rod to vary the coupling between the coils, a source of alternating current for one of the coils, and means for measuring the variations in the coupling between the coils as a measure of the variations in the diameter of the well bore.

The references relied on are:

Kinley et al	2,267,110	Dec. 23, 1941
Allen	1,946,924	Feb. 13, 1934

The caliper of Fig. 2, comprises a pair of pivoted arms 22 link connected to a rod 16 which passes through a packing 17 into container 3, partially filled with liquid. In the container there is a coil 40 supplied by alternating current through a conductor 11 which passes "sealably" through cap 13 at the other end of container 3. The rod 16 carries a coil 44 and register 45 connected by cables 46 to an indicator or recorder. As the arms 22 follow the variations of the diameter of the hole of the well shown normally filled with liquid, due to a compression spring 25, the rod 16 slides up or down in the container 3, and varies the inductance coupling between coils 40 and 44
which variation is indicated or recorded electrically
274 at the surface as a measure of the change of the
well bore. Change in volume displaced due to movements of rod 16 is compensated by the air chamber 31 thereby permitting easy sliding movement of 16.

Fig. 3 shows a modification employing a capacitance instead of an inductance coupling.

Election of species was required in accordance with Rule 41 and in paper No. 4, applicant elected Fig. 2, first described.

Claim 8 stands finally rejected on the ground of estoppel in view of applicant's expressed election.

The reference to Kinley shows a caliper for wells in which a rod 42 slides in response to pivoting movement of the calipering arms in the well and operates resisers or rheostats which control an electrical indicator 29 at the surface as a measure of variation of the well diameter.

In order to permit movement of the measuring rods 42 and prevent entrace of well liquids to the instrument container, Kinley provides a bore 60 containing a piston 61 which seals the bore and fills the container with a liquid such as light oil. The pressure between the inside and outside is thus equalized and any variation in displacement due to movement of the rods is taken up by movement of the piston.

Claim 7 is fully anticipated by Kinley except for the statement "a quantity of liquid partially filling said chamber so as to provide a space in the chamber above the liquid to serve as a compression chamber to compensate for volumetric changes produced by movement of the rod."

It was a well recognized fact at the time Kinley entered the field that it was practically impossible under the high presssures existing in wells to seal an instrument container against the entrace of well liquids and in
275 order to avoid this difficulty Kinley provided the
sliding sealing piston 61 in bore 60, which normally operated to maintain the pressure on both sides of the piston equalized and also compensated for volumetric changes produced by movements of his measuring rods.

The conventional sealing means were not sufficient to prevent the entrace of liquids as implied by Kinley. Applicant does not disclose any sealing means which will produce this result but contents himself with the statement that his conductor cable "sealably" passes through the cap 13. It is believed apparent that if a conventional seal is sufficient the sealing piston 61 of Kinley is sufficient and it would be a mere matter of degree not amounting to invention to only partially fill the instrument container with liquid in which event it would operate exactly as stated by applicant. If a conventional seal is not sufficient the well liquids will enter the container and prevent applicant's device from operating in the manner intended. The device would therefore lack patentable utility.

Claims 9-11 do not involve the feature just discussed but claim more specifically the inductance measuring means, in different phraseology. In the patent to Allen there is shown in Fig. 8 a calipering mechanism comprising a relatively fixed coil 62 included in An A. C. circuit (Fig. 11) and a movable coil 61 responding to variations in the object being measured. The variation in inductance coupling is measured remotely by a means 28. It is believed that only mechanical skill would be involved in substituting the inductance calipering mechanism of Allen for the resistance calipering means of Kinley.

It will be noted that applicant himself was aware
276 of the equivalence between resistance responsive and
inductance responsive devices for accomplishing the
same purpose as indicated by the modification illustrated
in his Fig. 1.

Respectfully,

E. C. Pugh
Examiner, Division 62.

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Paper No. 12b

277 *Examiner's Statement*

This is an action under Dual Prosecution by Division 48 on claims 12, 14, 15, and 19. General jurisdiction of this case is in Division 32.

The final rejection from which appeal is taken included that of claims 12, 14, and 15, finally rejected by Division 48, also claim 19, which as now amended belongs with this group, which claims are as follows:

12. The improvement in the art of investigating geological structures penetrated by a well bore which comprises the steps of simultaneously, measuring at various depths within fluid in the well bore the combined electrical characteristics of the fluid and the surrounding formations, and measuring the variations in the diameter of the well bore at the various depths, and correlating the log reading obtained with the variations in diameter to determine the effect on the log readings of the variations in diameter as ascertained.

14. In the art of formulating an electrical log of an open well bore where the indications obtained are affected by diameter of the column of drilling mud or liquid in the well bore, the step of obtaining electrical logging readings and simultaneously therewith obtaining a measurement of the diameter of the bore at the elevation at which the readings are being taken, and correcting the reading obtained for variation thereof caused by variations in diameter of the column of liquid logged because of the variation in the diameter of the bore.

15. A method of simultaneously obtaining an electrical logging reading in a well bore and measuring the diameter of the bore so that the readings may be correlated to correct the log reading for variations attributable to different diameters of drilling mud or liquid in the well bore

which comprises manipulating the electrical logging instrument and a well calipering instrument upon the same supporting mechanism from the surface so that the electric log reading and the diameter measurement are assuredly taken at the same elevation.

19. In the art of preparing an earth bore for
278 the production of petroleum the steps, of lowering
an apparatus into the well bore which is capable of simultaneously electrically logging and measuring the variations in the diameter of the bore so as to obtain information of the electrical characteristics of the earth formations penetrated by the bore and correcting such logging information as it may be varied due to variation in the measured diameter of the bore.

References relied upon:

Bazzoni	2,167,630	Aug. 1, 1939
Ennis (A)	2,228,623	Jan. 14, 1941
Ennis (B)	2,317,039	Apr. 20, 1943
Lee	2,313,384	Mar. 9, 1943
Kinley (A)	2,102,080	Dec. 14, 1937
Kinley (B)	2,267,110	Dec. 23, 1941
Huber	2,072,950	Mar. 9, 1937

Applicant's Disclosure

Applicant discloses a method of logging a well bore to obtain continuous records both of the well bore diameter and of an electrical formation characteristic throughout the well, then locating a well casing, cementing, and gun-perforating in accordance with the information supplied by the diameter log and the electrical log.

As the claims 12, 14, 15, and 19 considered by Division 48 are limited to the method of simultaneously logging the bore hole for both diameter and an electrical characteristic, the discusson of disclosure is here limited to that method.

The measurement of electrical characteristics is of "spontaneous earth potentials or—resistivity". Such measurements have been in common use for many years, and no novelty in any such a measurement per se is alleged or claimed.

Similarly, although the claims considered by Division 62 define alleged novel caliper structure, no novelty in the method of calipering as well to obtain a diameter log is alleged or claimed.

Applicant's alleged novelty here lies in combining the two, in the feature that both logs are made at the same time, with both the calipers for the diameter log and the electrodes for the electrical log supported in the same general location in the well bore by a single cable. Applicant also states at page 1, lines 27-29, that "if the 279 well bore contour were known, a correction factor could be used for correcting the readings in accordance with variation in the size of the bore". Nothing further is stated as to how this correction can be or is made.

Reference Disclosures

Bazzoni et al	2,167,630
Ennis (A)	2,228,623
Ennis (B)	2,317,039
Lee	2,313,384

Each of these references teaches that different values commonly investigated in a well bore may be investigated simultaneously and in the same location in the well bore, by means of a single cable. Suitable indicating apparatus may be located in the electrode carrier within the well or, by using conductors in the support cable, at the earth's surface.

Typical unknown values commonly investigated in bore holes include for example formation resistivity, spontaneous potential, fluid pressure; bore hole diameter, direction, and slope; earth temperatures, fluid conductivity, etc. In each case, a record is made of the desired value plotted against the depth at which it is taken, as the logging apparatus moves through the bore hole. The depth is conventionally determined by the length of support cable unreeled from the surface, with certain minor corrections for variance in temperature, suspended weight, etc. where great accuracy is desired. By support of a plurality of investigating or operating devices from a single cable, the operator is continuously assured that all corresponding test values or operations are located at the same level.

In Bazzoni et al, see page 6, column 2, lines 15-23. Ennis (A) shows some various combinations of means for placing a marker, for perforating a casing, and for locating a marker or an identifiable stratum by means of an electrical log recording device such as 39 and connected de-
280 vices in Fig. 2, 69 in Fig. 3, 76-79 in Fig. 4, 76 in Fig. 5. Ennis (B) in Fig. 9 shows means on a single cable for conditioning the well fluid and for making an electrical fluid test or an electrical earth formation test. Lee discloses a method for simultaneous temperature and electrical surveys, with the test means supported from the same cable and at the same elevation. See elements 68 and 80 in Fig. 9 of Lee.

Through all of these references therefore, as through many others, runs the teaching that a plurality of values may be investigated simultaneously by a plurality of means supported at the same elevation in the well by a single cable.

Kinley (A)	2,102,080
Kinley (B)	2,267,110

illustrate known methods and means for securing logs of well diameter, from which the well contour may be determined and suitable information gained.

Huber 2,072, 950 teaches a method of making simultaneous electrical tests, discusses incidentally the known effect of variation in the diameter of the bore hole, and makes an adjustment to compensate for difference in diameter. See page 4, column 1, lines 18-40.

Basis for Rejection

Each of claims 12, 14 and 15, also claim 19 as now amended subsequent to final rejection, is held clearly unpatentable over reference art.

Claim 12, 14 and 19 are additionally held to be unsupported by the disclosure.

Claim 15 is perhaps the broadest claim. The only step defined by this claim is "manipulating the electrical logging instrument and a well calipering instrument upon the same supporting mechanism from the surface", so that
the values measured are at the same elevation in
281 the well. The step of manipulating two measuring
instruments upon the same supporting mechanism
is the same regardless of what the instruments themselves may be. The common use of this method per se is clearly illustrated by each of Bazzoni, Ennis, Lee and Huber. If this method step could be considered patentable, it would necessarily be because one of the "instruments" is defined as a "well calipering instrument", a structural limitation upon a process claim which clearly is not a proper basis for allowance of a method claim. Even if this factor could be overlooked, the making of two well known tests simultaneously by supporting both test elements from the same support structure at the same elevation is shown by the references to be so well known that merely applying this abstract concept to any two or more of the tests commonly performed in well bores, unsupported by any detail as to how the tests are performed, is clearly unpatentable regardless of which specific test values may be under investigation. In this connection, see the decision by the Board

of Appeals in the Doll application S. N. 190,652, now patent 2,317,259, which stated:

"The essential difference discussed in this appeal is whether patentability can be predicated upon combining old drill hole measurements so that they are taken simultaneously.

It is our view that the advantages (of such simultaneous measurement) are obvious ones and that broadly there was no invention in combining old measuring systems for simultaneous operation."

It appears that claim 15 actually defines not so much a method as a mere result of a single undefined step; that considered as pure method, it is fully met by reference art; and that as a structurally limited method claim, 282 it is not only improper in form, but also depends wholly upon a structural difference that is clearly unpatentable. No adequate reason for allowance of so broad a claim can be found.

Claims 12, 14 and 19 are held to be unpatentable over the same art, and also as unsupported by applicant's disclosure. They add by one wording or another the feature of (claim 12) "correlating the log reading obtained with the variations in diameter to determine the effect on the log readings of the variations in diameter as ascertained". This particular claim is indefinite because "log reading" has no antecedent, to indicate whether it is the electrical log or diameter log referred to. Assuming this indefiniteness is not sufficient in itself to invalidate the claim, it is apparent that the patentability of claim 12 over claim 15 and over the reference art must rest entirely on some disclosed process for "correlating—to determine the effect on the (electrical) log readings of the variations in diameter". But upon reference to the specification, no such disclosed process can be found. Lines 27-29 of page 1 say that "a correction factor could be used". Lines 17-19 of page 5 state that "correlation" of the logs is "important". But as to how the correlation is made, or how the correction factor is used, or in fact how the correction factor is obtained and what it is, the specification is completely silent.

If such correlation or correction involves novelty in itself, obviously these claims 12, 14 and 19 fall for lack of adequate disclosure concerning the very feature on which patentability must depend. If such correlation or correction can be regarded as broadly within the knowledge of those skilled in the art, as might possibly be inferred from Huber, the fact that it might be so regarded would by necessary consequences make it unpatentable. This, 283 together with the fact that in the broad sense all logs for any one well are "correlated" to provide all possible information, necessarily would make these claims not patentable over reference art.

All of claims 12, 14, 15 and 19 appear clearly unpatentable over the references. Claims 12, 14 and 19 are unsupported by adequate disclosure. The final rejection of these claims, therefore, is necessary, and should be affirmed.

Respectfully submitted,

S. Bernstein
Act. Examiner, Division 48.

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Paper No. 12

284 *Examiner's Statement*

This is an appeal from the final rejection of claims 7-19, inclusive, all of the claims now in the case. Claims 7-11 are treated in the accompanying statement by Division 62 under "Dual Prosecution." Claims 12, 14, 15, and 19 likewise are treated in the accompanying statement by Division 48. The remaining claims 13, 16, 17, and 18 treated herein by Division 32, which has general jurisdcition of the case, read as follows:

13. In the art of obtaining information for the preparing an earth bore for the production of petroleum the steps of, simultaneously electrically logging and measuring the variations in the diameter of the bore so as to obtain information of the electrical characteristics of the earth formations penetrated by the bore and to correct such information as it may be varied due to variation in the diameter of the bore, positioning a casing within the bore, introducing an amount of cement as indicated by the diameters measured which will effect the cementing of the casing above the area and below the area of productive formation is indicated by the log, and thereafter perforating the casing at said indicated formation.

16. A method of obtaining penetration of the shot into a productive formation in a well bore where the formation is washed out to a larger diameter than the bore during drilling by excluding such area from cementing which comprises calipering the well bore to ascertain the location, presence, diameter and extent of the washout, running a casing into the well, cementing the casing at spaced elevations above and below the washed out area so as to avoid filling the wash out with cement which might not be penetrated by the shot, and shooting the casing to form perforations therein at the non-cemented area at the elevation of the washout.

17. A method of obtaining penetration of the
285 shot into a productive formation in a well bore
where the formation is washed out to a larger diameter than the bore during drilling by excluding such area from cementing which comprises calipering the well bore to ascertain the diameter location, presence, and extent of the washout, running a casing into the well, cementing

the casing at spaced elevations above and below the washed out area so as to avoid filling the wash out with cement which might not be penetrated by the shot, shooting the casing to form perforations therein at the non-cemented area at the elevation of the washout, and simultaneously on the same calipering device supporting an electrical logging mechanism to determine the nature and characteristics of the washed out formation.

18. A method of obtaining penetration of the shot into a productive formation in a well bore where the formation is washed out to a larger diameter than the bore during drilling by excluding such area from cementing which comprises calipering the well bore to ascertain the diameter location, presence, and extent of the washout, running a casing into the well, cementing the casing at spaced elevations above and below the washed out area so as to avoid filling the wash out with cement which might not be penetrated by the shot, shooting the casing to form perforations therein at the non-cemented area at the elevation of the washout, simultaneously on the same calipering device supporting an electrical logging mechanism to determine the nature and characteristics of the washed out formation, and correcting the determination of such logging mechanism for variation due to the presence of an additional volume of drilling mud or liquid in the washed out area.

The following art is relied upon as anticipatory:

"Tomorrow's Tools Today"—Volume 5, No. 1, January 1939, pages 2 and 3.

Ennis	2,228,623	January 14, 1941
Kinley	2,102,080	December 14, 1937
Kinley et al	2,267,110	December 23, 1941

The alleged invention relates to a surveying apparatus for use in well bores and to methods including the operation of that apparatus. The apparatus comprises a caliper for surveying the bore hole and recording, at the surface, the log of its diameter. The claims drawn to this apparatus are treated by Division 62.

One group of method claims recites the simultaneous logging of the bore hole for both diameter and electrical charactertistic. Division 48 treats this group of claims.

The remaining claims recite the method comprising electric logging, diameter measuring, positioning a casing, cementing the casing, and gun perforating it at a specified region. Such claims are treated herein.

286 The specification states that the petroleum formation sometimes is relatively soft so that mud pumped out through the bit under high pressure may wash out the formation for a considerable distance radially of the bore. After the open hole is logged, a casing is set therein, and cemented in place. Cementing includes pumping cement around the outside of the casing whereby any cavity will be filled with cement. If the cavity which was filled by cement is in the formation to be produced, attempts to perforate and complete the well at that level might be unsuccessful. The thickness of cement might be so great as to prevent the desired penetration of the shots from the perforating gun.

The specification teaches that where the electric logging and calipering operations show a washout to be present at the producing formation "squeeze cementing" should be resorted to above and below the cavity to avoid filling it with cement.

The publication discloses "A Typical Example" of well drilling, logging, casing running, cementing, and perforating, in column 1 of page 3. A hole was drilled by the rotary method to 5,208 feet. The operator ran an electrolog in the open hole. He ran the casing and cemented at 5,208 feet with 150 sacks (a small amount of cement). He cemented the upper stage at 3,725 feet with 175 sacks (likewise a small amount of cement). He employed the "Dual Seal Cementer" (illustrated and described on page 2) for cementing the upper stage. The operation left the space between 5,208 feet and 3,725 feet free from cement. The enlarged, center figure on page 3 clearly shows this condition to exist, a body of liquid extending up to the upper mass of cement. The operator then perforated between 5,140 feet and 5,167 feet, as well as between 5,181 feet and 5,204 feet, into the clear.

The patent to Ennis is cumulative. It discloses running an electric log in an open hole (Fig. 6), cementing in a casing (Fig. 4), and gun perforating (Figs. 4 and 7).

The Kinley patents disclose calipering an open
287 hole and recording in the form of logs the information obtained.

Claim 13 was rejected first as being functional and indefinite. The cementing operation as recited in the last four lines is almost entirely funtional. The only cementing step positively set forth is "introducing an amount of cement as indicated by the diameters measured which will effect the cementing of the casing above the area and below the area of productive formation as indicated by the log." At best, this language appears to direct the operator to obtain a mass of fluent cement whose volume is somehow related to the diameters measured and to drop (or otherwise "introduce") that single mass of cement into the well. Such a procedure obviously would not accomplish the desired results of separately sealing two restricted regions behind the casing respectively above and below the productive formution. The claim accordingly is indefinite and fails to point out the invention in the manner required by the statutes.

Claim 13 was further rejected and claims 16, 17, and 18 were rejected as being drawn to aggregations of unrelated features. It seems evident that no patentable relation exists between the specific method of logging the well to determine the character of the formations traversed on the one hand and the method of setting casing, cementing the casing, and perforating it, on the other hand. While it may be desirable to measure the volume behind the casing at the region in which the cement is to be placed, this may be done otherwise than by calipering and the cementing, etc. is not dependent upon a combined calipering and electric logging procedure. The electric logging, likewise is wholly independent of any specific use to which the information gained thereby may be put. It is not restricted to use in relations where the well is subsequently completed in the manner set forth in these claims.

Where the two processes thus are not dependent upon each other, it is well settled that the claims are unpatentable. In re Grapp, 1933 C. D. 386, 64 F (2d) 376
288 the Court of Customs and Patent Appeals quoted the following language of the Board of Appeals with approval:

"The Examiner rejects these claims as being for aggregation. It appears that the step of forming this buffer sheet is not in any way depending on afterwards using it as a component part of a mattress. This so-called buffer material might be useful in many relations where a relatively strong stiff felt-like material is necessary such as an insulating layer in building construction or for carpet padding. The broad step of laying it up with the body of the mattress is likewise not dependent on how the buffer sheet is formed. Other buffer sheet material might be used in the same way in the alleged process without in any way affecting the order of the steps or results considered as a method. We consider this ground of rejection warranted.

It cited In re Harris 37 App. D. C. 374, 170 O. G. 484 in which the Court of Appeals of the District of Columbia quoted with approval the following language of the Commissioner of Patents:

"There is believed to be no essential relation between the three steps of preparing, storing, and dispensing the beverage, which applicant successively employs. Each step appears to be complete in itself and independent of the other. The claims covering these successive steps are in the nature of an aggregation of unrelated functions performed by appellant's apparatus."

The quoted language, it is submitted, applies as well to the facts presented by the case at bar as it did to the facts then before the courts.

Claims 13, 17, and 18 include the electric logging in combination with the specific well completing process and accordingly seem clearly to fall within the disapproval of the decisions cited. Claim 16 does not include the electric logging but it does include the calipering in combination with the well completion steps. It too, therefore, is considered to set forth an aggregation of unrelated features. Calipering is not the only method by which information for calculating the volumes at the points in question may be obtained.

The only direct connection between the logging and/or calipering on the one hand and the cementing and perforating of the casing on the other is in the mind of the operator.

If for any reason claims 13, 17 and 18 could be found directed to a proper combination, it is believed then
289 that they should be held rejectable on the ground
of exhausted combination. These claims accordingly were further rejected as being drawn to an exhausted combination in view of either the publication "Tomorrow's Tools Today" or the patent to Ennis. The publication, for example, clearly discloses electric logging, positioning

a casing, cementing the casing at spaced elevations above and below the producing horizon, and gun perforating the casing at the producing horizon. This is the general organization of steps set forth in these claims (the calipering as here recited is a part of the electric logging operation, being employed to determine the "correction factor" to be applied to the logging data). Specific features of the electric logging, one of the elements, cannot add to the patentability of the combination. In re Plummer, 130 F (2d) 758, 1942 C. D. 719 (C. C. P. A. 1942); In re Lincoln, 126 F (2d) 477, 29 C. C. P. A. 942, 1942 C. D. 386.

The patent to Ennis cumulative on this phase of the question.

Claims 13, 17, and 18 were rejected additionally on "Tomorrow's Tools Today" in view of the patent to Bazzoni and either of the two Kinley patents. As held by the Examiner of Division 48, Bazzoni discloses that electrical measuring apparatus and any well surveying apparatus may be lowered on the same cable and operated simultaneously. Such surveying apparatus may be of any known type, as the calipers employed by Kinley. The substitution of such combined electric logging and calipering for the simple electric logging suggested in the publication would not require the exercise of inventive skill.

Claim 16 likewise is rejected additionally on the publication "Tomorrow's Tools Today" in view of either of the two Kinley patents. It recites calipering the well bore, running a casing, cementing the casing at spaced elevations above and below a washed out area, and shooting the casing at the elevation of the washout. This method seems of doubtful utility for it has not been shown that all washed out areas are necessarily in hydro-
290 carbon or other valuable fluid producing horizons.
There appears to be no utility in performing the method at a level where desirable fluids cannot be obtained.

In any event, the calipering of the hole described in the publication in the manner taught in either of the Kinley patents would not require the exercise of inventive skill. The avoidance of cementing a wash out, especially if it be at a producing area, would seem but an ordinary act of prudence. As previously pointed out, the publication discloses cementing at areas spaced above and below the producing horizon.

For these reasons, it is respectfully submitted that the final rejection was proper and should be sustained.

Respectfully submitted,

Karl R. Fisk
Examiner

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Paper No. 17

291 BEFORE THE BOARD OF APPEALS

Ex parte Alonzo L. Smith

Application for Patent filed September 20, 1941, Serial No. 411,761. Well Surveying Device and Method.
Lester B. Clark for applicant.

This case is under triple prosecution and applicant has appealed from the decision of each of the Primary Examiners of Division 32, 48 and 62. The claims under rejection are claims 7 to 19, which are all of the claims now in the case.

Claims 7 to 11 were treated by Division 62; claims 12, 14, 15 and 19 by Division 48; and claims 13, 16, 17 and 18 by Division 32.

The following claims are taken as typical:

7. In a well surveying device the combination of, a housing having a chamber therein and adapted to be low-

ered into a well bore, a rod extending into said housing, means for moving said rod in accordance with variations in the diameter of the well bore, means operable by the movements of said rod for indicating at the surface the variations in the diameter of the well bore causing such
movement, and a quantity of liquid partially filling
292 said chamber so as to provide a space in the chamber
above the liquid to serve as a compression chamber to compensate for volumetric changes produced by movement of the rod.

8. In a well surveying device the combination of a housing adapted to be lowered within a well, caliper arms pivotally attached to said housing, means normally urging said arms resiliently outwardly into engagement with the walls of the well, a variable capacitance within said housing, means operable by movements of said rod for varying said capacitance, and means at the mouth of the well bore and electrically connected to said capacitance for exhibiting the variations in the capacity thereof as a measure of the diameter of the well bore.

12. The improvement in the art of investigating geological structures penetrated by a well bore which comprises the steps of simultaneously, measuring at various depths within fluid in the well bore the combined electrical characteristics of the fluid and the surrounding formations, and measuring the variations in the diameter of the well bore at the various depths, and correlating the log reading obtained with the variations in diameter to determine the effect on the log readings of the variations in diameter as ascertained.

13. In the art of obtaining information for the preparing an earth bore for the production of petroleum the steps of, simultaneously electrically logging and measuring the variations in the diameter of the bore so as to obtain information of the electrical characteristics of the earth for-

mations penetrated by the bore and to correct such information as it may be varied due to variation in the diameter of the bore, positioning a casing within the bore, introducing an amount of cement as indicated by the diameters measured which will effect the cementing of the casing above the area and below the area of productive formation as indicated by the log, and thereafter perforating the casing at said indicated formation.

The following references have been cited:

Ennis	2,228,623	Jan. 14, 1941
Ennis	2,317,039	Apr. 20, 1943
Kinley	2,102,080	Dec. 14, 1937
Kinley et al.	2,267,110	Dec. 23, 1941
Allen	1,946,924	Feb. 13, 1934
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Lee	2,313,384	Mar. 9, 1943
Huber	2,072,950	Mar. 9, 1937

"Tomorrow's Tools Today"—Volume 5, No. 1, Jan. 1939, P. 2 and 3.

The appeal has been withdrawn as to claim 15.

293 Taking up first claims 7, 8, 9, 10 and 11, we consider claim 7 to patentably distinguish from Kinley et al., cited against it. In Kinley et al. it seems that volumetric displacement of fluid from the chamber requires the piston to be moved against the well pressure whereas this is avoided in applicant's construction in which a volume of air or gas is exposed to compression for the purpose.

As to claims 8, 9, 10 and 11 Kinley et al. states that instead of the resistors specifically shown any suitable mechanism available for indicating variations in electrical conditions in an electric circuit may be used, and in our opinion no invention is involved in using the mechanisms of Allen in place of resistors.

Claims 12, 14 and 19 relate to simultaneously obtaining electrical log readings and bore diameter readings along the well bore and then correlating the simultaneously made readings. We understand that applicant does not claim to be the first to have correlated electrical log readings and bore diameter readings made at the same places in the bore at different times. The act of correlating the readings would be the same whether the readings were produced simultaneously or at different times. One set of readings might be different from the other set for the reasons stated by applicant but the procedure of correlating them would be the same. Accordingly we see no patentable significance in this correlating step.

294 As to taking the readings simultaneously we agree with the examiner that in view of the references showing it to be old in the art to take two different readings in a well bore simultaneously, and each of the steps of taking the readings included in the claims being old, no invention is involved in taking these two particular readings simultaneously.

Claim 19 is drawn to the intended use of the apparatus and is objectionable as a method claim.

As the claims are worded we do not consider the correlating step to be unsupported by the disclosure but we agree with the examiner's rejection of the claims otherwise.

The third group of claims consists of claims 13, 16, 17 and 18. The publication cited discloses cementing at spaced locations along a well bore, but does not mention whether there are or are not any washed out areas intermediate the places where the cement is applied. Presumably there would be, at least on occasions. We agree it would not amount to invention to measure the diameter of the bore where the cement is to be applied to ascertain what quantity of cement to use, or to correlate electrical

readings and diameter readings taken along the bore to locate productive areas. As the examiner points out there seems to be no point in avoiding the cementing of a washed out area which is non-productive. The cited publication teaches that a productive area should not be cemented so that the casing can be readily perforated at that area and the flow brought in without interference from cement.
This obviously is intended to apply to productive
295 areas regardless of whether the areas are washed
out or not. Accordingly we fail to see how the claims patentably distinguish from the references cited against them.

The examiner has also rejected claim 13 as functional and indefinite and claims 13, 16, 17 and 18 as drawn to an aggregation of unrelated features. Claim 13 may be interpreted as meaning that the cement is introduced and the cementing effected above and below the productive area, the correct amount of cement to use being first ascertained. We do not consider this claim objectionably functional or indefinite.

The combined electrical and diametrical logging locates the productive areas, the diametric logging also disclosing the correct amount of cement to introduce, and perforating the casing between the cemented areas brings in the flow. Claims 13, 16, 17 and 18 do not seem to us to merely aggregate non-cooperating steps and the examiner's rejection of these claims on this ground is not sustained. However, as stated, we consider the claims unpatentable over the art cited against them.

The appeal as to claim 15 is dismissed.

The decisions of the Examiners of Divisions 32 and 48 are affirmed and the decision of the Examiner of Division

62 is affirmed as to claims 8, 9, 10 and 11 and is reversed as to claim 7.

March 22, 1945

Henry Van Arsdale
Assistant Commissioner

C. S. Shaffer
Examiner-in-Chief

V. J. Richard
Examiner-in-Chief

BOARD OF APPEALS

Lester B. Clark
2200 Gulf Bldg.
Houston, Texas

* * * *

Paper No. 19

296 Ex parte Alonzo L. Smith

Application for Patent filed September 20, 1941, Serial No. 411,761. Well Surveying Device and Method. Lester B. Clark for applicant.

On Request for Reconsideration

Applicant petitions for reconsideration of our decision of March 22, 1945.

The petition appears not to raise any points that were not presented and carefully considered before. The points have been reconsidered but we are still of the opinion that our previous decision was correct.

It seems to us that it is not of patentable significance whether the records obtained by one of the two simultaneously made independent readings is used to modify the records obtained by the other reading or not. Such correlation of the records is a mental procedure.

297 Consideration has been accorded but the petition is denied as to making any change in our decision.

Henry Van Arsdale
Assistant Commissioner

C. H. Shaffer
Examiner-in-Chief

V. J. Richard
Examiner-in-Chief

BOARD OF APPEALS

183 SMITH v. OOMS—Civil Action No. 30,662

A—Allen et al.,	1,946,924
B—Huber,	2,072,950
C—Kinley,	2,102,080
D—Bazzoni et al.,	2,167,630
E—Ennis,	2,228,623
F—Kinley et al.,	2,267,110
G—Lee,	2,313,384
H—Ennis	2,317,039
I—"Tomorrow's Tools Today"—Vol. 5, No. 1, Jan, 1939, pages 2 and 3.	
I′—Print of Drawings,	

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Feb. 13, 1934. A. ALLEN ET AL **1,946,924**

CALIPERING MECHANISM

Filed Feb. 18, 1928 2 Sheets-Sheet 1

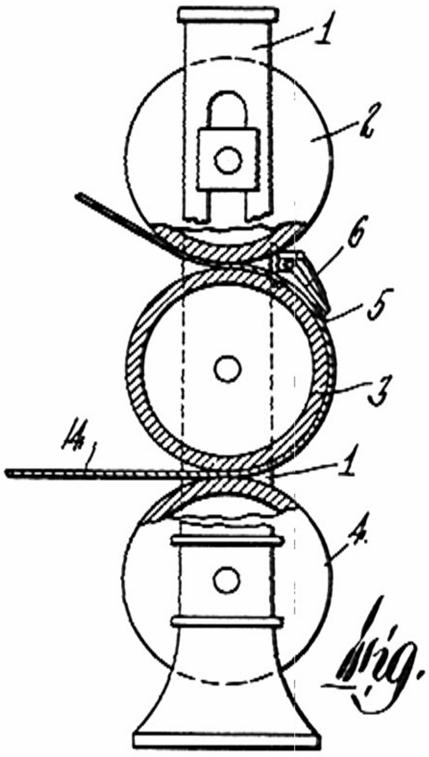

Fig. 1.

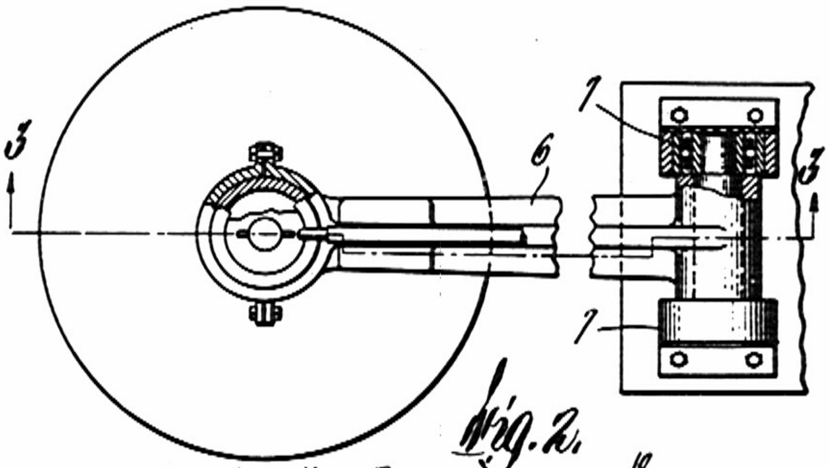

Fig. 2.

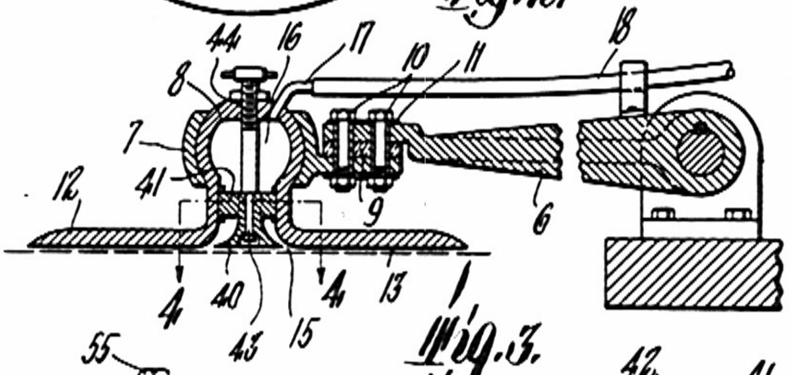

Fig. 3.

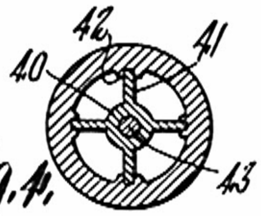

Fig. 4.

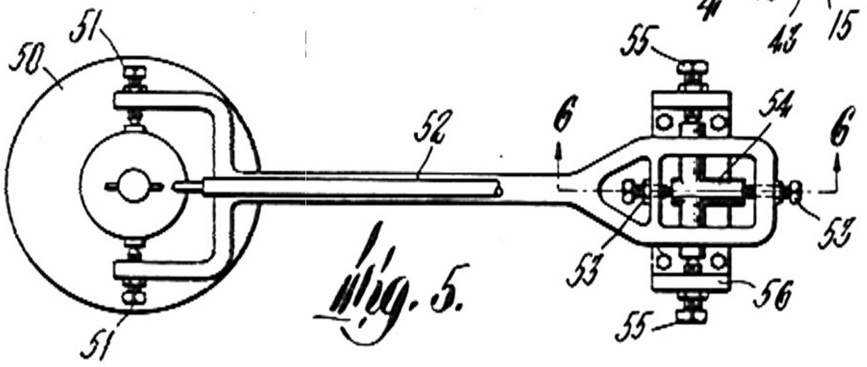

Fig. 5.

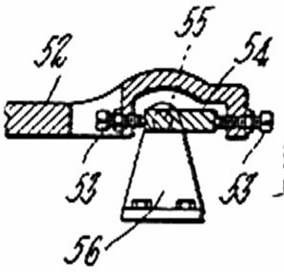

Fig. 6.

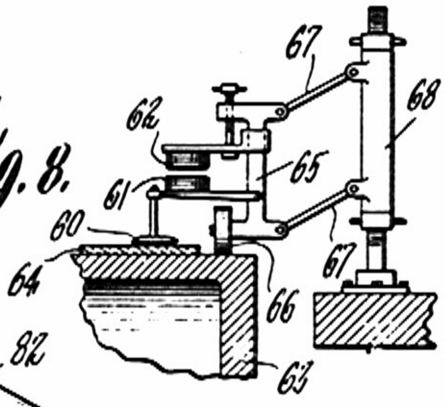

Fig. 8.

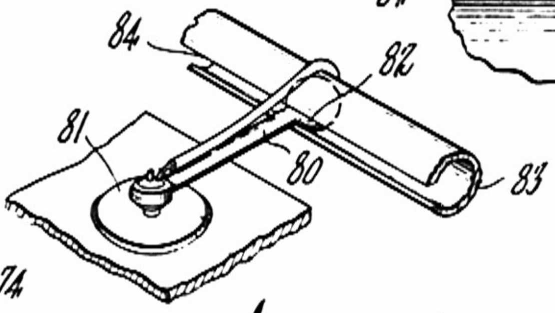

Fig. 7.

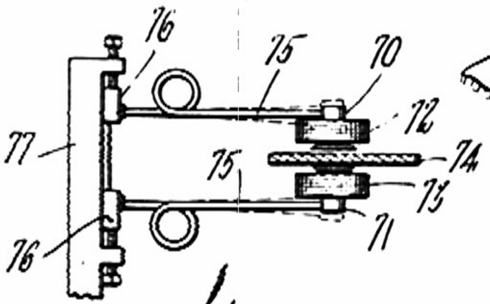

Fig. 9.

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Feb. 13, 1934. A. ALLEN ET AL **1,946,924**

CALIPERING MECHANISM

Filed Feb. 18, 1928 2 Sheets-Sheet 2

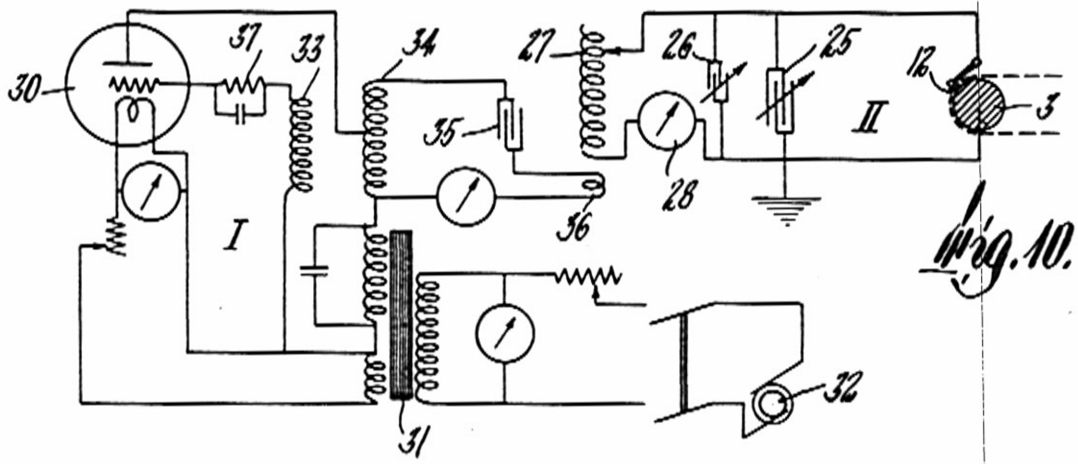

Fig. 10.

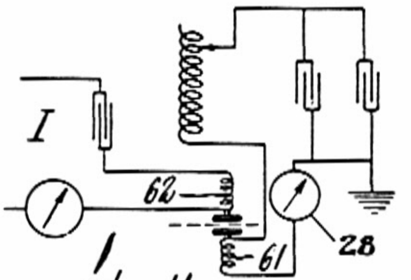

Fig. 11.

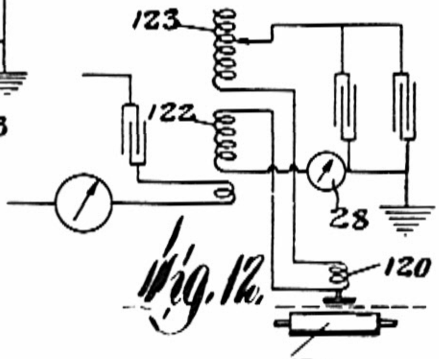

Fig. 12.

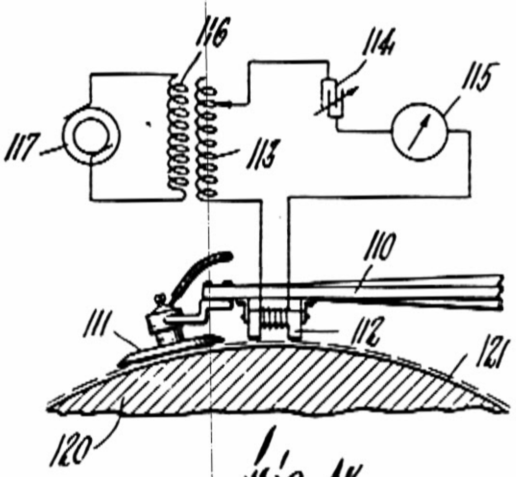

Fig. 13.

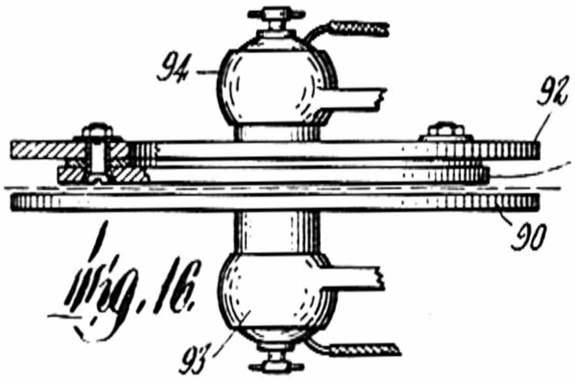

Fig. 16.

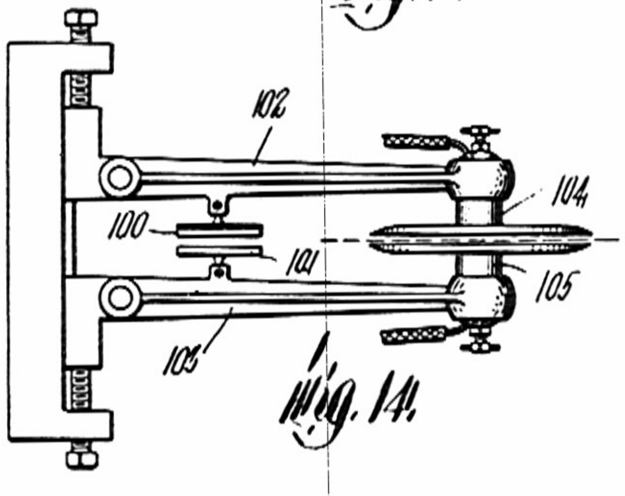

Fig. 14.

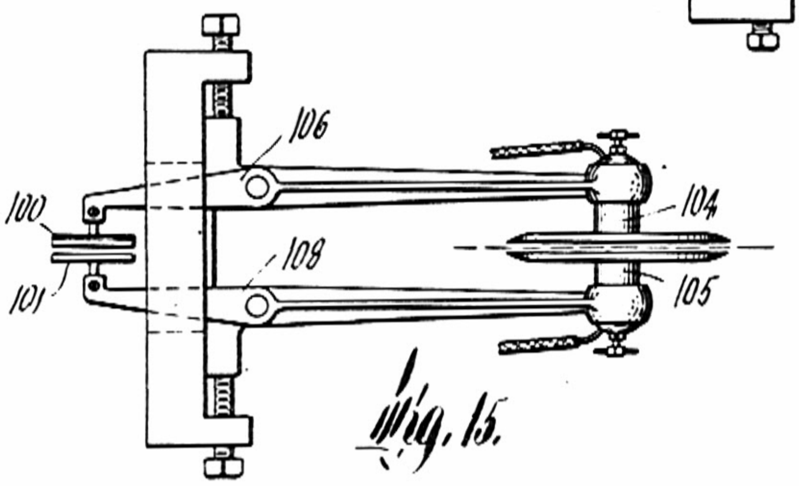

Fig. 15.

Inventors:
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UNITED STATES PATENT OFFICE

1,946,924

CALIPERING MECHANISM

Albert Allen, Winchester, and John G. Callan, Cambridge, Mass., assignors to Atlantic Precision Instrument Company, Boston, Mass., a corporation of Massachusetts

Application February 18, 1928. Serial No. 255,364

9 Claims. (Cl. 33—125)

It has been attempted heretofore to measure the thickness of sheet material by the use of a calipering element riding on its surface. Where the surface of the sheet material is slightly rough like that of ordinary paper and the element rides lightly thereon, it rides on the prominences and therefore it fails to give an indication of true average thickness. If it be attempted to apply pressure to crush down the prominences the amount to which they are crushed down is quite indefinite and depends on many conditions which can not be accurately controlled. For example in the case of paper the character of the fiber, the amount of beating and the moisture content of the calipered material would have an effect impossible to determine. In the case of measuring thickness of rubber, the character of the rubber and more particularly its temperature, are important factors to determine the extent to which the element will press down the surface under any given pressure. In some instances also pressure on the element would act to mar the surface of the material and detract from its value.

The present invention, therefore, has for an object the calipering of material by means which may determine a true average thickness and without the use of a calipering element directly contacting with the material, this being subject to the various limitations, inaccuracies and disadvantages heretofore mentioned.

A further object is to produce such a mechanism by which the thickness indication, however derived, may be indicated or recorded at a distance and by which, if desired, correcting mechanisms may be controlled tending to maintain the thickness of a moving web or sheet at a predetermined value.

In order to carry out the first mentioned object this invention makes use of a principle which exemplified in a rudimentary form has sometimes been termed the "pneumatic paradox". This comprises a simple disk or spool fed with compressed air through a hole in its center which is used to hold a piece of paper or like material closely to its face where the air issues, the paradox consisting in the fact that the sheet material is held close to the disk instead of being driven away therefrom by the force of the issuing jet of air.

The principle involved is that of an over-expanding nozzle obeying laws that constitute slight modifications of the well known laws of nozzle expansion particularly familiar to the designers of elastic fluid turbines. The elastic fluid fed to the relatively small central area—as for example the hole in a common spool placed adjacent to a card—turns to a direction parallel to the flat face of the disk and flows outwardly across progressively increasing sectional areas, transforming pressure head into velocity head and thus establishing a mean pressure over the disk which in a considerable range of proportions is less than the pressure of the external air into which the elastic fluid discharges at the outward periphery of said disk.

By application of the principles of nozzle design the effect of the "pneumatic paradox" and particularly the definiteness of the gap between the face of disk and the adjacent surface can be maximized.

In order to carry out the second mentioned object the position of the calipering element, and thereby the thickness of the material being calipered, is accurately indicated by a sensitive electrical mechanism the sensitivity of which is quite capable of indicating the caliper with the great accuracy with which a calipering element employing the pneumatic paradox principle can be made to maintain a calipering position.

For a more complete understanding of this invention, reference may be had to the accompanying drawings in which

Figure 1 is an elevation partly broken away of a stack of rolls through which sheet material is passed showing one form of calipering element constructed according to this invention in operative position.

Figure 2 is a top plan on a larger scale and partly broken away of one form of the calipering element.

Figure 3 is a section on line 3—3 of Figure 2.

Figure 4 is a detail section on line 4—4 of Figure 3.

Figure 5 is a top plan of a different form of element.

Figure 6 is a detail section on line 6—6 of Figure 5.

Figure 7 is a perspective illustrating a further modification.

Figures 8 and 9 are fragmentary views illustrating two methods of using such calipering elements.

Figure 10 is a wiring diagram for the method of use shown in Figure 1.

Figures 11 and 12 are fragmentary wiring diagrams, Figure 11 illustrating the use of the mechanism shown in Figure 9.

Figure 13 is a fragmentary view somewhat diagrammatic showing another manner of use of the calipering element.

Figures 14, 15 and 16 are views illustrating various ways of using opposed calipering elements for controlling the position of condenser plates, thereby to vary the capacity of the condenser formed by these plates in accordance with the thickness of the material being calipered.

Referring first to Figures 1, 2 and 3, in Figure 1 is indicated at 1 a calender stack having calender rolls 2, 3 and 4. Material to be calipered, as at 14, is fed through this stack between the rolls 2 and 3, about one side of the roll 3, and then between the rolls 3 and 4. At 5 is shown a calipering element which lies adjacent to the outer face of the sheet material as it passes about the roll 3 and may rise or fall with variations in thickness of such material, being pivotally carried by the arm 6. This calipering element is shown more in detail in Figures 2 and 3. The arm 6 is shown as pivoted on the ball bearing supports 7 carried by a fixed portion of the calender frame, and as shown in Figure 3, its outer end portion is formed as a ball socket 7 for the reception of a ball portion 8 of the calipering element. This socket portion 7 is shown as insulated from the remaining portion of the arm 6, for a purpose which will later appear, as by means of the insulating strip 9 interposed between portions of the arm 6 and the ball socket, the three parts being fixed together as by means of the bolts 10 passing through insulating washers 11. The ball portion 8 is a part of a disk shaped calipering element 12 having a face 13 preferably slightly curved to conform closely to the curvature of the outer face of the sheet material 14 as it passes about the roll 3. While this is not essential in all cases it adds to the accuracy with which the calipering element responds to variations in thickness of the sheet material. This element 12 is centrally apertured as at 15, this aperture communicating with the hollow interior 16 of the ball portion 8 into which compressed gas such as air may be introduced through the pipe 17 which may be connected to a suitable source of air or other gas under pressure as by means of the flexible rubber tube 18.

The energy of the air issuing from the opening 15 is converted from pressure energy to kinetic energy as it is expanded between the outer face of the calipering element and the surface of the material being calipered, and its kinetic energy causes it to be over-expanded, that is, expanded to below atmospheric pressure, so that the atmosphere acting on the opposite face of the disk causes the disk to ride very close to the surface of the material being measured. The closeness with which it rides to the surface is dependent on the rate at which the compressed gas can escape around the edges of the element and also somewhat on the pressure of the gas and the size of the disk. With the same material, therefore, the position which the element occupies is controlled by the average thickness of the material and not by merely the thickest portions thereof as is the case with the ordinary calipering element which rides lightly directly on the face of the material. This calipering element, therefore, in effect floats at a predetermined distance from the average position of the face of the material and it is found in practice it holds to a given position with great accuracy and great tenacity so that its position may be used to indicate accurately the thickness of the material.

In order that an indication of the sensitiveness comparable with the accuracy with which such an element holds to its position may be had, this element may be used to control certain characteristics of an electric circuit capable of measuring very small changes in its position.

As shown in Figure 10, this element may be used as one member of a tuning condenser for one of a pair of high frequency oscillatory circuits arranged in the relation of primary and secondary circuits I and II, respectively, forming a high frequency transformer system. Thus the roll 3 may be grounded through the frame of the calender stack as illustrated in Figure 10 while the element 12 may form the opposite condenser plate which is arranged in series with tuning condensers 25 and 26 in the secondary oscillatory circuit II, which also contains an inductance 27 and a current measuring device 28.

By means of the tuning condensers 25 and 26 or through the variation of inductance 27, or both, the natural free period of the secondary circuit may be brought near to resonance to that of the primary exciting circuit I. This circuit, as shown, comprises a thermionic tube 30 which may derive its filament and plate voltage through a transformer 31 from a suitable source of alternating current indicated at 32. This primary circuit may have inductances 33 and 34 and a capacity 35 and may be coupled inductively or otherwise to the secondary circuit. As shown in Figure 10 it is inductively coupled by means of the coil 36, in inductive relation to the coil 27 to the secondary circuit II. At 37 is shown the usual grid resistance and condenser for oscillatory circuits of this description.

Changes of the spacing between the condenser plate 12 and the roll 3 will thus act to determine the detuning between the primary and secondary circuits which are tuned slightly out of resonance with each other, thus to determine the current response in the secondary circuit, and thus to change the indication of the instrument 28. This circuit is of the general type illustrated in the patent of Albert Allen for Indicating and controlling method and mechanism for paper making machines and the like, No. 1,708,074 granted April 9, 1929, but this invention is not dependent on any particular circuit.

In order that the effect of the component of pressure of the expanding gas under pressure issuing from the nozzle 15, which tends to separate the element 12 from the sheet material may be minimized, means are preferably provided, such as shown in Figure 3, to close off the central portion of the opening 15 so that the gas issuing therefrom may issue more nearly parallel to the outer face of the element. As shown in Figures 3 and 4 a generally frusto-conical element 40 may be used for this purpose, this element 40 being provided with fins 41 radiating therefrom at its smaller end which are positioned between guide ribs 42 projecting inwardly from the wall of the opening 15. The element 40 is centrally apertured for the passage of a headed rod 43, the outer end of which is threaded as at 44 and passes through the rear end of the ball head 8. By turning this rod 43 the position of the element 40 lengthwise of the opening 15 may be regulated as desired. This element 40 fills the central portion of the opening 15 and defines therewith an annular discharge orifice through which the issuing gas is conducted between the face of the disk 12 and the face of the material to be calipered with little component directed so as to tend to force the element away from the face of the material. The ball socket arrangement permits the calipering element to conform itself to the general contour of the surface of the material so that the action of the compressed gas during its expansion is substantially uniformly exerted.

In Figures 5 and 6 is shown a modified construction by which this limited universal motion of the calipering element may be produced. According to this construction the calipering disk 50 is mounted to swing about an axis formed by bearing screws 51 carried by the yoked outer extremity of the supporting arm 52. This supporting arm 52 is provided with similar bearing screws 53 arranged at right angles to the bearing screws 51, these bearings screws 53 engaging opposite arms of a T shaped element 54 which in turn is supported by bearing screws 55 from an anchoring plate 56, the bearing screws 55 being arranged at right angles to the bearing screws 53. The arm 52 is thus supported on gimbal joints from the anchoring plate 56 for rocking and axial turning while the calipering element is mounted for rocking about an axis at right angles to the rocking axis of the arm 52 so that the universal movement of this calipering element is provided.

There are many ways in which the position of the calipering element may be used to control the response of the electric circuit. Certain of these, in addition to that previously described, have been here illustrated. In Figure 8, for example, the calipering element 60 may be used to control the position of an inductance 61 with reference to an inductance 62. The position of the inductance 62 is controlled by the surface of a roll 63 over which the material 64 to be calipered passes. As shown this is accomplished by supporting the inductance 62 adjustably on an arm 65 carrying a roller 66 which rides on the margin of the roll 63 beyond the edge of the material 64. This arm 65 is guided for parallel movement by a pair of links 67 pivoted thereto and to a support 68. The inductance 62 thus follows the surface of the roll 63 and the inductance 61 follows the position of the upper face of the material 64 so that the nearness of these inductances to each other is dependent on the thickness of the material 64.

This construction may be taken advantage of to control the current response of the secondary circuit, as shown in Figure 11, the inductance 62 as shown being in the primary circuit I and the inductance 61 being in the secondary circuit, the nearness of these inductances to each other representing the degree of coupling between the two circuits.

In Figure 9 still another method of using such a calipering element has been indicated. Referring to this figure, it will be seen that two such elements are employed as at 70 and 71, each having an inductance coil as 72 and 73 thereon. These elements 70 and 71 are spaced so as to permit the passage of the material to be measured as at 74 therebetween and they are so mounted as to be free to take up positions relative to opposite faces of the material 74 as they may be impelled to do by the action of the expanding gas between them and the adjacent faces of the material. As shown each is mounted at the outer end of a resilient arm 75, each arm being supported in a block 76 adjustably carried on a fixed support 77. The inductance coils 72 and 73 may be arranged in the circuits similarly to the coils 62 and 61 of Figure 11.

Sometimes it may be desired to so mount the element that it may be moved along the face of the material being measured, as for example when it is desired to caliper different widthwise portions of a traveling sheet and this may be done as shown in Figure 7 in which the supporting arm 80 of the calipering element 81 may have a ball end 82 mounted to ride lengthwise within a tube 83 extending across the machine and having a slot 84 through which the stem of the member 80 may extend freely.

Instead of using an inductance or utilizing the calipering element itself as an element of a condenser, it may be utilized in other relations. For example, as shown in Figure 16, where two elements are employed between which the material passes, one of these elements as at 90 may be used directly as one plate of a condenser which may be grounded and the other as at 91 may carry in insulated relation therewith an annular plate 92 which may serve as the ungrounded or high frequency plate of the tuning condenser. This plate 92 is preferably of an outside diameter substantially that of the opposite calipering element 90. As shown these elements are mounted in ball joints as at 93 and 94 similar to the construction illustrated in Figures 2 and 3.

If desired also the condenser plates may be independent of the calipering elements, as illustrated in Figures 14 and 15. In Figure 14 these condenser elements are shown as plates 100 and 101 which are carried by the arms 102, 103 which support the opposed calipering elements 104, 105. In Figure 15 the supporting arms for the calipering elements are extended on the opposite side of their pivots as at 106, 108, these expanded portions carrying the condenser plates 100 and 101.

In Figure 12 an inductance 120 is shown as spaced from the metallic mass as of a roll 121 over which the material to be calipered is passed, this spacing being determined by the calipering element riding on the gas film on the opposite face of the material from the metallic mass. This inductance 120 is shown as in series with inductances 122 and 123 of the secondary oscillatory circuit which is excited by the primary circuit such as is shown completely in Figure 10. The inductance value of the inductance 120 is varied by variations in its spacing from the metallic mass by variations in caliper of the material being tested, eddy currents being induced in the metallic mass by the current in the inductance which react thereon. Thus the tuning of the secondary is varied with variations in caliper, which varies the current flow in the secondary.

It is also possible, but with less accuracy, to use an alternating current of ordinary frequency in the indication of the position of the calipering element. One method of doing this is illustrated in Figure 13 in which the arm 110 which carries the calipering element 111 carries also a horseshoe electro-magnet 112. This magnet is in series with an inductance 113, a variable capacity 114 and a current indicating instrument 115. The inductance 113 is placed in coupling relation to a primary coil 116 energized from a suitable alternating current source as at 117. Variations in the position of the calipering element 111 with relation to the metallic roll 120 over which the material to be measured passes, as at 121, causes variations in inductance of the horseshoe magnet winding 112 thus to vary the closeness to resonance between the circuit containing the indicator 105 and the primary alternating current circuit containing the inductance 116, these circuits being brought initially near to resonance to each as by manipulation of the condenser 114 or the inductance 113, or both, as may be required.

By reason of the electrical indication it is possible to produce such indication at any desired point, and through the use of suitable relays such as those shown in the Allen application for patent hereinbefore referred to, it is possible to set in motion corrective mechanisms to tend to maintain the caliper as indicated by the instrument, at a desired value.

Certain embodiments of this invention having thus been described it should be evident to those skilled in the art that various changes and modifications may be made without departing from the spirit or scope of this invention as defined by the appended claims.

We claim:

1. A mechanism of the class described comprising a plate, means for supporting said plate for movement into a position with one face closely adjacent to one face of sheet material which it is desired to caliper, means for introducing a compressed gas between said material and said face to be expanded to below atmospheric pressure therebetween, and means for indicating the resultant position of said plate relative to the opposite face of said sheet material.

2. A mechanism of the class described comprising a disk, means for supporting said disk with capability of universal turning and of bodily motion toward and from a face of material to be calipered, a member having a definite position with respect to the opposite face of said material said disk having an opening centrally thereof, means for introducing a gas under pressure through said opening between said disk and the adjacent face of said material, and means for indicating the resultant position of said disk relative to said member.

3. A mechanism of the class described comprising a disk, means for supporting said disk with its face closely adjacent to the face of the material to be calipered, a member having a definite position with respect to the opposite face of said material said disk having a central opening therethrough flaring toward the adjacent face of said material, means for conducting gas under pressure to said opening to pass between said material and disk, and means for indicating the relative spacing of said disk and member.

4. A mechanism of the class described comprising a pair of plates, means for supporting said plates yieldingly spaced to permit sheet material to be passed therebetween, said mechanism including means for expanding a compressed gas to below atmospheric pressure between each of said plates and said sheet material, and means responsive to the resultant spacing of said plates to indicate the caliper of said material.

5. A calipering element presenting a disk-shaped face to the surface of material to be calipered, said element having a central perforation therethrough flaring toward said face, and a member seated centrally in said perforation at said face and defining with the wall of said perforation an annular nozzle.

6. A calipering element having a face formed to lie closely against a surface of material to be calipered, said element having a perforation therethrough through which a gas under pressure may be introduced between said face and surface, and means for reducing the component of pressure of said gas tending to drive said element and material away from each other.

7. A calipering element comprising a disk having a face formed to lie closely against a surface of material to be calipered and a perforation opening in said face, and having an extension from the opposite face thereof terminating in a hollow spherical head, the hollow of said head communicating with said perforation opening in said first mentioned face, a support having a bearing for said head permitting universal pivotal movement of said element, and means for conducting a gas under pressure to the entrance of said head to escape through said perforation.

8. A calipering element comprising a disk having a face formed to lie closely against a surface of material to be calipered and a perforation opening in said face, and having an extension from the opposite face thereof terminating in a hollow spherical head, the hollow of said head communicating with said perforation opening in said first mentioned face, a support having a bearing for said head permitting universal pivotal movement of said element, means for conducting a gas under pressure to the hollow of said head to escape through said perforation, and a member centrally disposed in said perforation defining with the wall thereof an annular discharge orifice for said gas.

9. A calipering element comprising a disk having a face formed to lie closely against a surface of material to be calipered and a perforation opening in said face, and having an extension from the opposite face thereof terminating in a hollow spherical head, the hollow of said head communicating with said perforation opening in said first mentioned face, a support having a bearing for said head permitting universal pivotal movement of said element, means for conducting a gas under pressure to the hollow of said head to escape through said perforation, a member centrally disposed in said perforation defining with the wall thereof an annular discharge orifice for said gas, and means for adjustably fixing said member in position.

ALBERT ALLEN.
JOHN G. CALLAN.

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March 9, 1937. F. W. HUBER **2,072,950**

METHOD OF AND APPARATUS FOR ELECTRICALLY EXPLORING EARTH FORMATIONS

Filed May 21, 1935 2 Sheets-Sheet 1

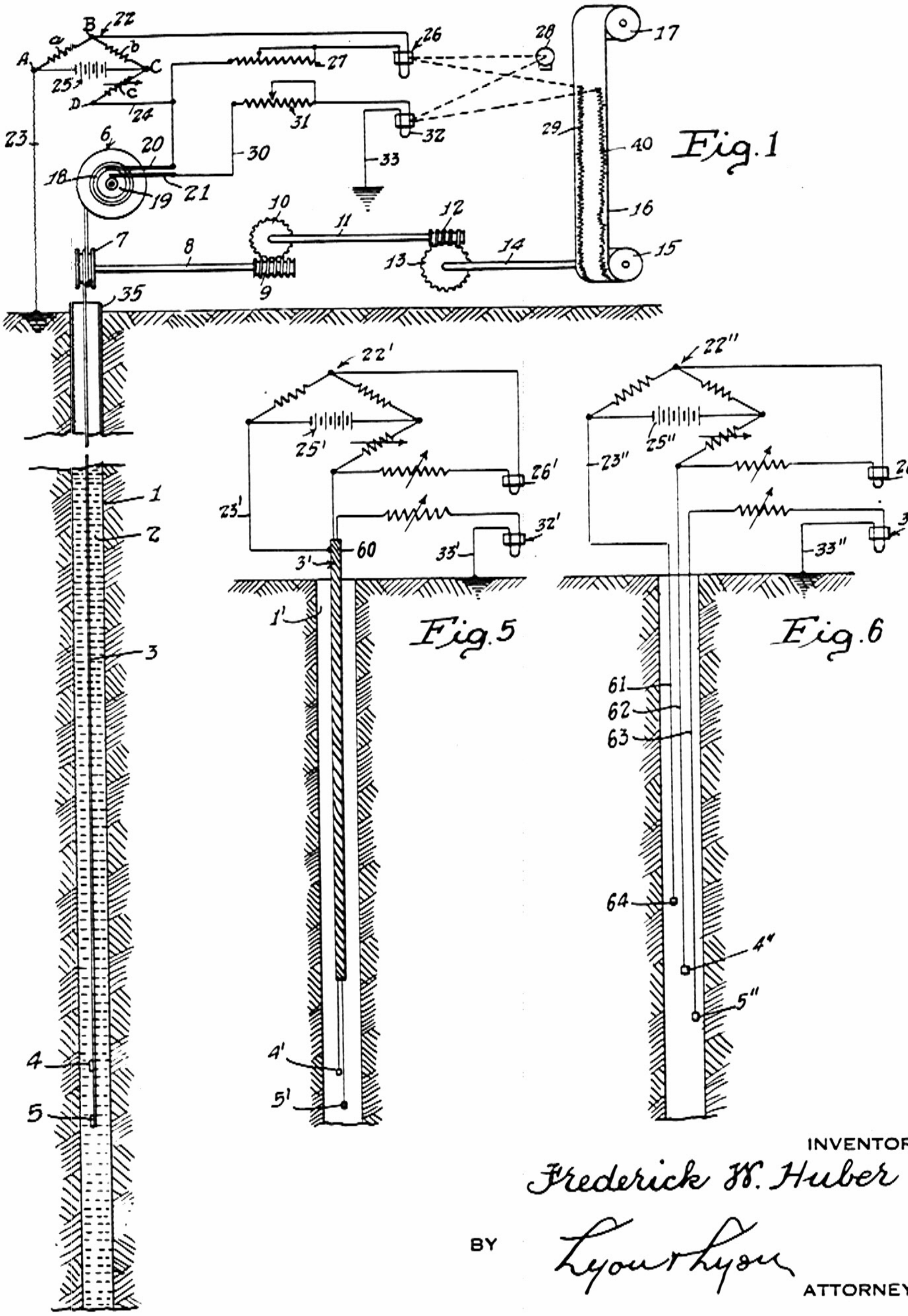

Fig.1

Fig.5

Fig.6

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METHOD OF AND APPARATUS FOR ELECTRICALLY EXPLORING EARTH FORMATIONS

Filed May 21, 1935 2 Sheets-Sheet 2

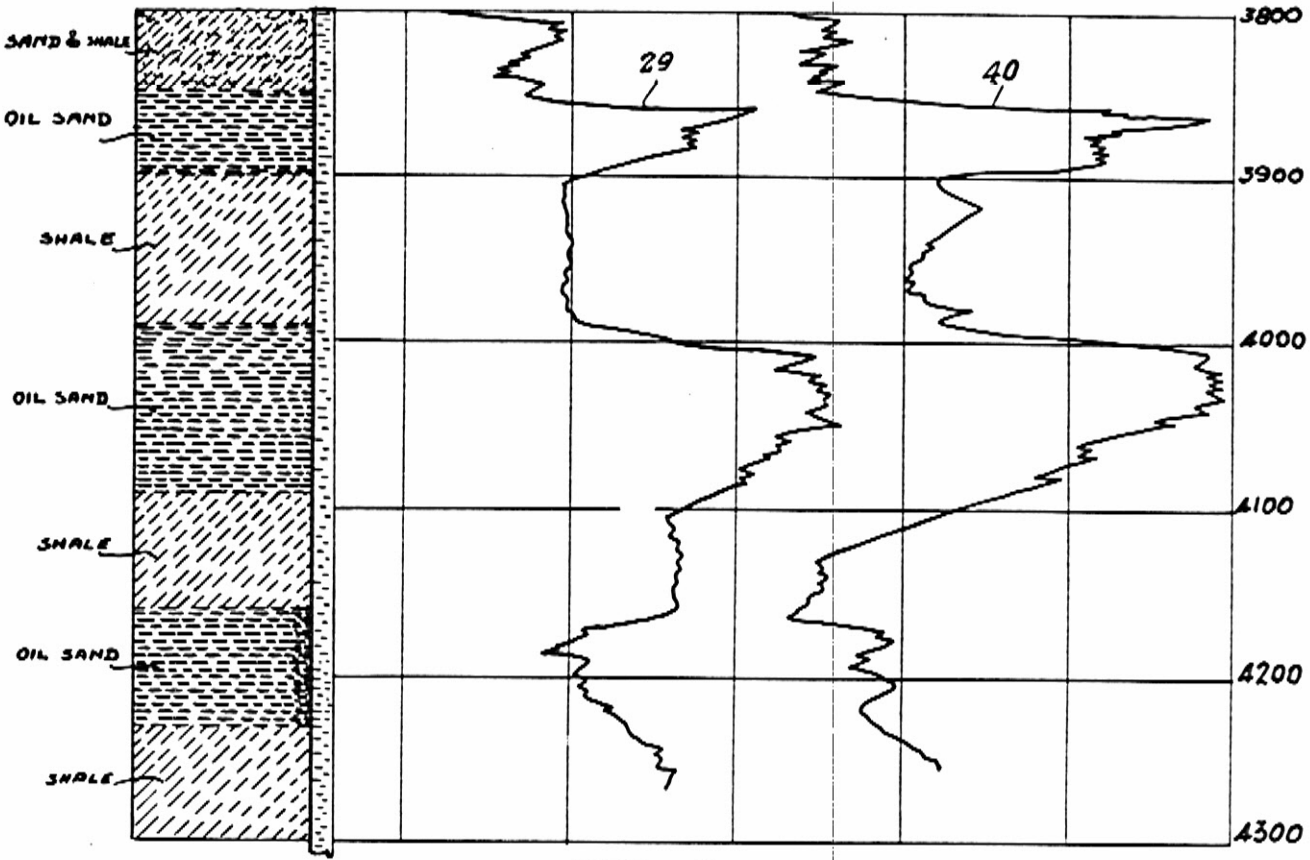

Fig. 2

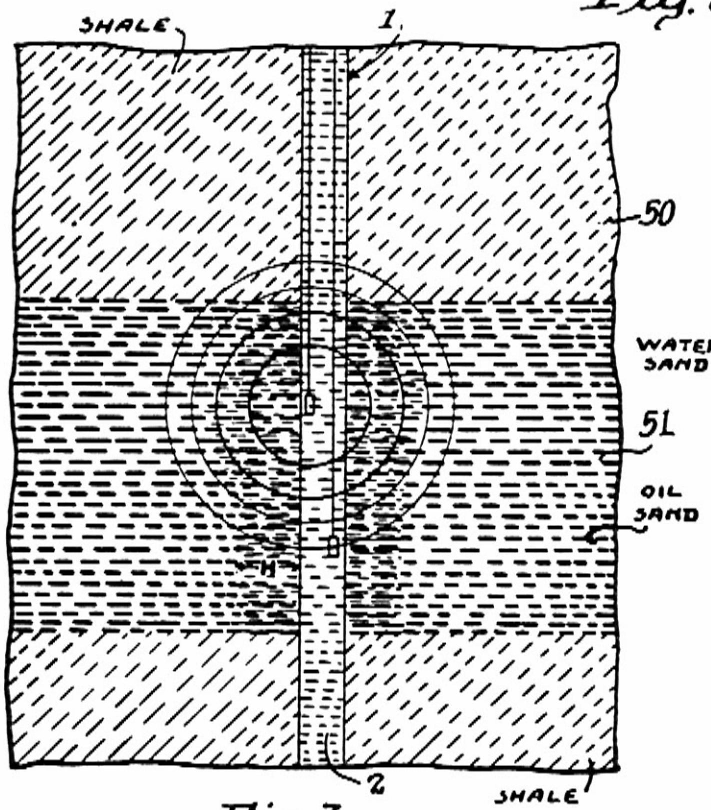

Fig. 3

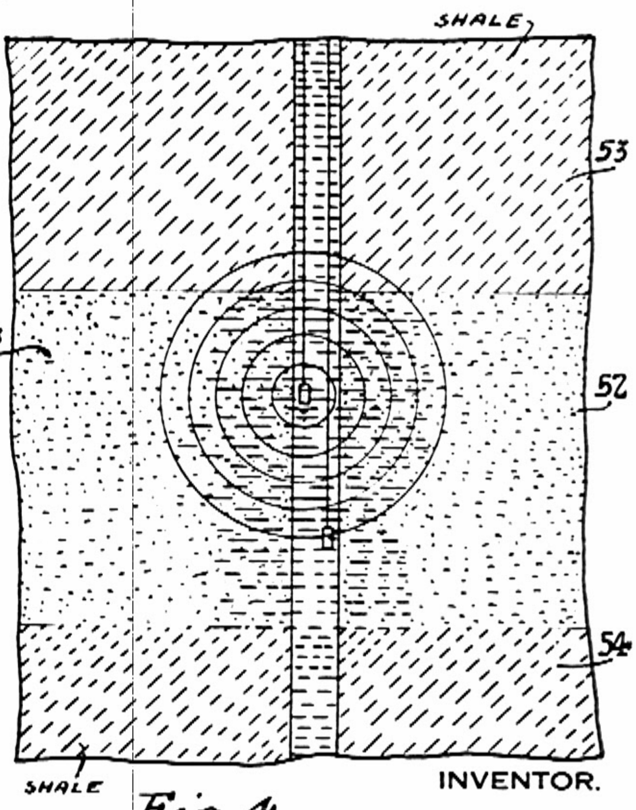

Fig. 4

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Patented Mar. 9. 1937 132 **2,072,950**

UNITED STATES PATENT OFFICE

2,072,950

METHOD OF AND APPARATUS FOR ELECTRICALLY EXPLORING EARTH FORMATIONS

Frederick W. Huber, Riverside, Calif., assignor to Geoanalyzer Corporation, Los Angeles, Calif., a corporation of California

Application May 21, 1935, Serial No. 22,533

6 Claims. (Cl. 175—182)

REISSUED
JUN 17 1941

This invention has to do broadly with the exploration of earth formations by electrical methods but relates more particularly to electrical explorations conducted through drill holes and has special application in connection with the mapping of formations penetrated by oil wells, water wells, and the like.

A broad object of the invention is to reduce the cost and time required in electrically exploring earth formations while at the same time increasing the amount of useful information obtainable from the exploration.

Various specific objects and features of the invention will be disclosed in the detailed description with reference to the drawings, which follows:

Some methods of electrical exploration of earth formations have been known for many years. Thus it is old to determine the specific resistivity of a body of earth in situ by means of the "four-terminal electrode" method which was first proposed by Searles of the United States Bureau of Standards and later elaborated by Wenner and applied by Gish and Rooney and others. This method has found extensive use in locating sub-surface minerals by means of electrical measurements made on the surface of the ground. The simplest way of practicing the four-electrode method is to employ four equally spaced electrodes disposed in a straight line and each making good electrical contact with the earth. The two outermost electrodes, called the input or current electrodes, are connected to an adequate current source, the circuit containing an ammeter. The two inner electrodes, called the potential electrodes, are not connected with the current source but have their leads connected to a potentiometer or other voltage measuring device. The current flowing between the two outermost electrodes creates an electric field in the earth between those electrodes and by means of the potentiometer the drop in potential in this field between the two potential electrodes is measured. Knowing (1) the value of the current flowing between the first two electrodes, (2) the distance between the electrodes, and (3) the potential difference between the potential electrodes, the specific resistivity of the earth between the potential electrodes can be deduced from the following formula credited to Wenner:

$$P=2\pi r\left(\frac{E}{I}\right)$$

in which

P=the specific resistivity of the earth between the specific electrodes;

r=the potential electrode spacing;

E=the difference in potentials between the potential electrodes; and

I=the current flowing between the input electrodes.

It has been experimentally found by Gish and Rooney that the depth to which the sub-surface may be explored by surface measurements is approximately equal to the distance the potential electrodes are spaced apart.

In the four-electrode methods devised by Searles, the potential electrodes may be positioned between the input electrodes or one or both of the potential electrodes may be positioned outside of the input electrodes.

The four-electrode method of Searles and Wenner for forming specific resistivities is applicable to making such measurements in a vertical as well as a horizontal plane (for instance, in a mine shaft or a bore hole) as long as the electrodes make good and sufficient electrical contact with the earth being explored. The problem of making good and sufficient electrical contact with the formation to be explored does not exist in a bore hole where good practice dictates that the hole be kept filled with the mud-laden drilling fluid. When applying the four-electrode method to measurements in a bore hole, a ground at earth surface can constitute one of the electrodes, three electrodes being employed in the bore hole, or there can be two grounds at earth surface and two electrodes down the bore hole. In each case, however, there are four electrodes and in each case specific resistivities are computed by applying Wenner's formula or a modification thereof.

However, Wenner's formula holds only for homogeneous earth masses of constant specific resistivity. Where the resistivity changes from point to point, factors and coefficients have to be introduced, which make the method at best but an approximation.

In all the prior methods known to me based upon the four-electrode principle, the specific resistivity is deduced from the current value flowing in the input circuit and the potential difference existing between the potential electrodes. The consecutive values of the specific resistivity obtained upon moving the electrode system throughout the length of a bore hole may be plotted to provide a curve trace from which the position of the discontinuities of the strata can be located. It is important to note, however, that by this system only one geologically significant curve is obtained, i. e., a curve indicating the position of the discontinuities. This curve does not indicate the nature of the fluid contained in the permeable strata penetrated by the bore hole.

In accordance with the present invention, I have discovered that the geological discontinuities of the strata penetrated by a bore hole can be located very accurately by a method not involving the four-electrode method and that the nature of the fluid in the porous strata can be definitely determined simultaneously by a modification of the four-electrode method without having to know the value of the current flowing in the circuit.

In accordance with my discoveries, I locate the discontinuities in the strata by recording deflections of a galvanometer in a single circuit consisting of a source of current connected between ground and an electrode movable through the bore hole. The galvanometer is located in a network in the circuit and this network and the method in which it is used constitutes one of the novel features of my invention.

More specifically, this circuit consists of an adequate current source connected across one diagonal of a Wheatstone bridge circuit with a galvanometer connected across the other diagonal. Three of the arms of the bridge are constituted by artificial resistances and the fourth arm is constituted by the resistance of the earth between the ground electrode and the movable electrode in the bore hole. It is old to measure resistance with a Wheatstone bridge, the well known method of procedure being to vary the artificial resistance in one or more of the arms of the bridge until no current flows through the galvanometer connected across one diagonal thereof. The unknown resistance is then computed from the values of the known resistances in the three arms of the bridge. This method gives very accurate results but has the serious objection in well surveying that it is slow, it being necessary to manually adjust the calibrated resistance elements of the bridge until a balance is obtained, as indicated by a zero reading of the galvanometer, before the resistance can be determined. In my system, instead of balancing the unknown resistance by a known resistance until a zero galvanometer reading is obtained, I merely determine the general nature of resistance variations as the electrode is moved through the bore hole by recording the deviations of the galvanometer needle from an arbitrary zero point (after the system has been adjusted to bring the galvanometer movements within a desired range). To limit the swing of the galvanometer needle to a suitable value, a large adjustable resistance is connected in series therewith. Although various methods of recording might be employed, I find it satisfactory to use a mirror on the galvanometer suspension which reflects a light beam from a fixed source onto a moving photographic strip, the motion of which is made to synchronize with that of the electrode traversing the bore hole, thereby tracing a curve which is some function of the changes in resistance of the formation adjacent the movable electrode in the hole at different levels in the hole. From the curve so traced, the discontinuities in the strata are located as will be more fully explained hereafter.

The curve obtained by the procedure just described not only locates the discontinuities of the strata but in a great many fields also gives an indication of the nature of the fluid contained in the permeable strata. However, there are fields in which this indication is not positive enough to warrant definite conclusions as to the nature of the fluid contained. In accordance with my invention, I have also discovered that this limitation may be overcome by introducing a second electrode at a fixed definite distance from the first electrode in the bore hole and recording the changes in the potential drop between this second electrode and the ground surface as the electrodes are moved through the hole. To record these potential changes, I prefer to employ a galvanometer with a large adjustable resistance in series therewith, the galvanometer suspension having a mirror thereon which reflects light from a fixed source onto a moving photographic strip which may be the same strip upon which the first mentioned curve is produced. The two curves when compared with each other give information which permits definite conclusions being drawn as to the nature of the fluid contained in the permeable strata, even though the drill hole fluid may have penetrated some distance into the strata and displaced the natural fluids therein.

It is most important to note that although the basis of my procedure is purely empirical, the results obtained are of great practical significance.

The apparatus and procedures employed in accordance with the invention will now be explained with reference to the drawings, in which

Figure 1 is a schematic view illustrating a preferred form of apparatus in accordance with the invention;

Fig. 2 is an explanatory chart showing the records obtained from exploring a formation with the apparatus illustrated in Fig. 1 in juxtaposed relation with a map of the formation penetrated by the well;

Fig. 3 is a schematic detail view, in cross section, showing that portion of a well bore lying within an oil sand, together with the electrodes of the exploring apparatus;

Fig. 4 is a view similar to Fig. 3, but showing the exploring electrodes located within a water-bearing sand stratum;

Fig. 5 is a highly schematic diagram illustrating an alternative type of exploring cable and associated circuit to that shown in Fig. 1; and

Fig. 6 is a schematic diagram showing still another alternative electrode and circuit arrangement.

Referring, first, to Fig. 1, an uncased bore hole 1 containing drilling fluid 2 is shown penetrating a formation to be explored. It may be assumed that the bore hole is in an oil field and intended to be a productive well, the fluid 2 consisting of the usual drilling fluid containing a suitable mud, which fluid was left in the hole following removal of the drill.

The exploring apparatus proper comprises an insulated cable 3 containing a pair of electrical conductors, each of which is connected at the lower end of the cable to separate electrodes 4 and 5, respectively. The cable 3 will have a total length somewhat in excess of the depth of the hole to be explored, which cable is normally wound upon a drum 6 positioned adjacent the top of the well. The cable is unwound from the drum 6 to lower the electrodes 4 and 5 into the hole, and is rewound upon the drum to raise the electrodes. Between the drum 6 and the hole the cable passes around a spool or drum 7 which functions to move a recording tape in synchronism with the movements of the electrodes 4 and 5. Thus the spool 7 is shown mounted on a wormshaft 8 bearing a worm 9 which meshes with a wormwheel 10 on one end of a shaft 11 upon the other end of which is mounted a second worm 12 which meshes with a wormwheel 13 mounted on a shaft 14 which turns a spool 15 to wind a photographic film 16, the film being supplied from a feed spool 17.

The two conductors within the cable 3 are connected to the electrodes 4 and 5, respectively, at the lower end of the cable and are connected at the opposite end of the cable to a pair of contact segments 18 and 19, respectively, on the exterior of drum 6, which segments are contacted by brushes 20 and 21, respectively. Segment 18 connects to the conductor associated with electrode 4, and segment 19 is connected to the conductor associated with electrode 5.

In operation, a substantially constant potential is impressed between ground and the electrode 4 and provision is made for indicating variations in the resistance between these points. To this end the brush 20 is connected to one terminal D of a Wheatstone bridge 22, an adjacent terminal A of which is connected to ground by a conductor 23. The conductor 23, the earth path from conductor 23 to the electrode 4, the cable conductor connected to electrode 4, the segment 18, the brush 20 and the conductor 24 extending between brush 20 and the terminal D constituting the unknown arm of the bridge 22, equal resistances *a* and *b* constitute the fixed arms of the bridge between terminals A and B and B and C, respectively, and an adjustable resistance *c* constitutes the arm of the bridge between terminals C and D. A constant potential is impressed across the terminals A and C by a source of potential 25 which is shown as a battery but may be a generator. The poles B and D of bridge 22 are connected to a recording voltmeter which may consist of a mirror galvanometer 26 connected in series with an adjustable resistance 27.

Although referred to as a mirror galvanometer, the device 26 is preferably a relatively rugged milliammeter, having a mirror mounted on its moving coil. This mirror is adapted to reflect a beam of light from a lamp 28 onto the sensitive film 16 to produce (after the film has been developed) a record 29.

The segment 19 and associated brush 21 are connected through the second conductor of the cable 3 to the electrode 5 which, as previously stated, is electrically distinct from and spaced a predetermined distance from the electrode 4. This electrode is connected through segment 19, brush 21, a conductor 30, adjustable resistance 31, and a second mirror galvanometer 32 to ground over a ground conductor 33. Galvanometer 32 functions to indicate variations in the potential drop between ground and electrode 5, which results from the earth current produced by the battery 25 between earth and the electrode 4. Galvanometer 32 is so positioned as to reflect a beam of light from the lamp 28 onto the film 16 at a point substantially juxtaposed to the beam from the galvanometer 26.

The electrodes 4 and 5 are first positioned within the hole adjacent the upper or surface end thereof, which portion of the hole is usually cased, as indicated at 35, and the bridge 22 is adjusted by adjustments of the resistance C until the galvanometer 26 produces a zero registration at a desired point on the film 16. This adjustment of resistance C to bring the galvanometer to the arbitrary zero reading is made without any reference to the value or direction of the current flowing through the galvanometer—there being no attempt whatever to balance the Wheatstone bridge and thus bring the galvanometer to zero indicating equal potential at B and D. Likewise the resistance 31 is varied to produce a predetermined desired deflection of the galvanometer 32 so as to position the beam reflected therefrom at a desired point on the film. Thereafter the cable is lowered into the hole at a uniform rate of speed to traverse the hole with the electrodes 4 and 5. At the same time the movement of the cable 3 rotates the drum 7 to cause the film 16 to be moved past the beams of light reflected thereon from the galvanometers 26 and 32, respectively, at a fixed speed relative to the movement of the cable.

Since the variations in total resistance of the circuit through the earth formation between the ground conductor 23 and the cable electrode 4 is largely dependent upon the resistance of the particular formation immediately adjacent the electrode 4, the resistance of that arm of the bridge between "A" and "D" varies with the movement of the electrode 4 past different formations. These variations in resistance cause variations in the ratios of the potentials existing across the different arms of the bridge and cause variations in potential between the poles B and D, which variations in potential produce deflections in the galvanometer 26 causing the beam of light reflected therefrom onto the film 16 to describe an irregular line upon the film.

The current flowing through the earth between the ground 23 and electrode 4 sets up an electric field in the earth, the relative intensity of the field in various points in the earth depending upon their distances from the electrodes and the various electrical properties of the strata adjacent those points. As the electrode 4 traverses the well bore, variations in the electrical properties of the strata traversed will therefore cause variations in the electrical field surrounding the electrode. In accordance with the discoveries of Gish and Rooney, these variations may be indicated by the use of the four-electrode system for a depth equal to the spacing of the potential electrodes.

Therefore the variations in the electrical properties of the formation between the hole and a point at a distance from the hole 1 substantially equal to the distance between the electrodes 4 and 5, causes a change in the potential between earth and the electrode 5, which changes in potential are impressed upon the galvanometer 32, causing the latter to describe an irregular line 40 upon the film 16. To provide for adjustment of the amplitude of movement of the galvanometers 26 and 32, respectively, the sensitivities of those instruments may be varied by adjusting the resistances 27, 31, respectively, which are connected in series therewith.

It will be apparent from the foregoing description that as the electrodes 4 and 5 are lowered through the hole 1 a record indicating at least the approximate variations in the resistance of the formation adjacent the hole, is made by the galvanometer 26, and, at the same time, a record of changes in the potential of the electrode 5 (which is a measure of the resistivity of the formation at a distance from the hole substantially equal to the distance of the electrodes **4** and **5**), is made by the galvanometer **32**. The fact that the recordings are made entirely automatically is of the utmost importance for the reason that it permits the electrodes to be run through the hole rapidly, thereby reducing the total time required for exploration and it also precludes any possibility of error due to the human element, such as frequently result where readings are taken by an observer and manually recorded.

The adjustable resistance **27** in series with the galvanometer **26** serves to regulate the total throw of the galvanometer needle from its established zero position. This makes it possible to vary the sensitivity of the galvanometer over a wide range and thus obtain any desired amount of detail on the curve trace produced. This is of great practical importance as the diameter of the hole and salinity of the drilling fluid in the hole influence the sensitivity to a marked degree. For example, if the sensitivity is adjusted to give good detail in a bore hole 6 inches in diameter, the same sensitivity adjustment when measurements are being made in a 12 inch hole would give little or no detail and the total throw of the galvanometer would be so small that the breaks in the curve would be more or less masked and the location of the discontinuities in the strata would not be indicated definitely. In other instances the salinity of the fluid in the bore hole might be such as to give too great a throw to the galvanometer needle, causing most of the curve to fall outside the limits of the recording strip or film. In practice, the sensitivity is adjusted by adjusting the resistor **27** immediately after the electrodes are lowered below the cased portion of the hole, at which level the bridge is adjusted, as previously described.

To prevent polarization effects, I prefer to run the electrodes through the hole at a speed of not less than 30 feet per minute. However, it is usually desirable, in order to conserve time, to run the electrodes at substantially higher speeds, and speeds up to 600 feet per minute have been employed with very satisfactory results.

It is to be understood that measurements may also be taken by moving the electrodes from the bottom of the hole up to the surface while making recordings instead of, or in addition to, making recordings while lowering the electrodes.

The records produced in the manner described, are preferably made on film which is calibrated longitudinally in accordance with the distance traversed by the electrodes in the well hole. A portion of such a record is indicated in Fig. 2, and I have shown juxtaposed to the record a map of actual earth formations traversed by the electrodes. The curve **29** represents variations in resistance between earth and the current electrode **4** and the curve **40** represents variations in potential between earth and the electrode **5**. The galvanometer **26** is preferably so poled that deflections to the right represent increased resistance adjacent the electrode **4** and the galvanometer **32** is so poled that deflection of curve **40** to the right represents a decreased potential impressed upon galvanometer **32**, which is indicative of an increased resistance in the formation at a distance from electrode **5** equal to the distance between electrodes **4** and **5**.

From an inspection of Fig. 2, it will be observed that at a depth between 3800 feet and approximately 3850 feet, where the electrodes were passing through a sand and shale formation, the curve **29** indicated a relatively low resistance and the curve **40** likewise indicated a relatively low resistance at a short distance from the hole. Thereafter, between the depths of substantially 3850 feet and 3900 feet the electrodes passed an oil sand which was indicated by rather violent deflections of the curves **39** and **40** to the right, indicating a higher earth resistance. Thereafter, from a depth of 3900 feet to substantially a depth of 4000 feet, the electrodes traversed a shale formation showing a relatively low resistance both adjacent the bore hole and at a short distance therefrom. Thereafter, from a depth of approximately 4000 feet to a depth of approximately 4100 feet, the electrode traversed an oil sand which increased the resistance adjacent both electrodes as shown by deflection of curves **39** and **40** to the right. From approximately 4100 feet to 4160 feet the electrodes again traversed a shale formation which is indicated on the curves **39** and **40** by relatively low resistance.

Below the last mentioned shale formation and extending substantially from a depth of 4165 to 4230 feet is an oil sand formation which would not be detectable from curve **29** alone. Thus it will be observed that in the oil sand formation which occurred at a depth between 3800 and 3900 feet the curve **29** was deflected violently to the right. Again in the oil sand formation between 4000 feet and 4100 feet curve **29** showed a sudden deflection to the right. However, from a depth of approximately 4160 to 4230 feet, curve **29** actually shows a deflection to the left, indicating a lower resistance adjacent the bore hole, which low resistance would, on its face, indicate a water sand rather than an oil sand (oil being a relatively poor conductor of electricity). However, it will be observed that whereas the curve **29** indicated a reduced resistance between the last mentioned depth, the curve **40** indicated an increased resistance. In other words, the two curves read together indicate that the resistance closely adjacent the bore hole decreased, whereas resistance at a distance from the bore hole increased. It has been found by experiments that the explanation of such an apparently anomalous result is found to be due to the fact that the pressure of the drilling fluid in the drill hole sometimes forces the oil in an oil bearing sand back away from the hole for a substantial distance the drilling fluid having relatively high conductivity replacing the oil in the sand immediately adjacent the hole. This condition is illustrated in Fig. 3, in which the hole **1** is shown passing through a shale formation **50** into an oil sand **51**. The drilling fluid **2** within the bore hole **1** has permeated the oil sand to the distance H, forcing the oil back away from the hole. Whenever the curves **29** and **40** separate, as shown in Fig. 2 adjacent the 4200 foot depth, it is strongly indicative of an oil sand which has been permeated to a greater or less extent by the drilling fluid in the well, the different recordings resulting from the fact that the resistance in the formation at a distance from the hole is substantially greater than the resistance of the formation closely adjacent the hole. This divergence enables the operator to distinguish a permeated oil sand from a water sand. Thus there is shown in Fig. 4 a water sand formation **52** between shale formations **53** and **54** which is likewise permeated to a greater or less extent by the drilling fluid **2** in the bore hole **1**. In this instance the resistance at a distance from the bore hole may be slightly greater than the resistance immediately adjacent the bore hole, but the resistivity at both points will be substantially less, for instance, than in the shale formations 53 and 54 immediately above and immediately below the water sand. In short, a divergence of the curves 29 and 40 indicates a divergence in the resistance characteristics of the formation adjacent the hole from the resistance characteristics of the formation at a distance from the hole equal to the spacing between the electrodes.

A formation, therefore, such as that shown at 52 in Fig. 4, would cause a deflection of both curves 29 and 40 to the left and the operator would be definitely apprised of the fact that the formation was not an oil or gas sand (oil and gas sand both having the characteristic of having a relatively high electrical resistivity).

The distance between the electrodes 4 and 5 usually varies between 2 to 15 feet, the optimum spacing depending upon the nature of the formation and the lateral distance to which the well fluid usually permeates an oil or gas sand. The current electrode 4 in Fig. 1 should be of substantial area, say from 25 to 100 square inches, in order to reduce the local resistance to a sufficient extent. The secondary electrode 5, however, may be very small as it does not have to carry appreciable current. The constants of the bridge 22 should be roughly proportioned to the resistances to be measured, and I have found it satisfactory to make resistances *a* and *b* 50 ohms; and the variable resistance *c* from zero to 200 ohms. The voltage of the battery, or other source 25, is usually between 100 and 200 volts which, with the resistance value specified in the bridge arms applies a voltage across the terminals A and B of from 35 to 85 volts. The resistances 27 and 31 are preferably variable from approximately 100 to 200,000 ohms.

Various modifications may be made in the circuit and apparatus of Fig. 1. Thus instead of coordinating the movement of the film 16 with that of the cable 3 by the mechanical linkage shown in Fig. 1, the cable and film may be caused to move in synchronism with each other by any known synchronizing mechanism, such as the well known Selsyn motors.

Also various modifications may be made in the electrical circuit shown. Two such modifications are shown in Figs. 5 and 6, respectively, in which elements corresponding to those in Fig. 1 bear the same reference numerals with the single prime mark added in the case of Fig. 5, and the double prime mark added in the case of Fig. 6. The showing of the film and the mechanism synchronizing the film with the cable, together with the cable, are omitted in Figs. 5 and 6 to simplify the drawings.

The arrangement shown in Fig. 5 differs primarily from that shown in Fig. 1 in the method of making the ground connection to conductor 23′. In Fig. 1 this ground connection was made by means of an electrode buried in the ground at any suitable point. In Fig. 5, the earth connection is made by employing a cable 3′ having an external metallic armor 60 to protect the cable from mechanical abrasion and employing this armor as the ground connection by connecting the conductor 23′ directly thereto. The conductor 33′ from galvanometer 32′ may also be grounded on the armor 60, if desired, although I generally prefer to connect this conductor 33′ to an independent ground.

It should be noted in this connection that it is not as important to have a low resistance ground connection for conductor 33′ as for conductor 23′ since the latter carries a substantial current whereas the current in the circuit including conductor 33′ is of negligible value. The metallic armor 60 of course must be terminated a substantial distance above the electrodes 4′ and 5′ in order to make the resistance of the circuit including the electrode 4′ sensitive to changes in the resistivities of the adjacent formation.

In Fig. 6 an arrangement is disclosed employing three electrodes connected to the surface by a cable having three electrically distinct conductors 61, 62, and 63, respectively. Conductors 62 and 63 are connected directly to electrodes 4″ and 5″ which correspond to electrodes 4 and 5 in Fig. 1, these electrodes being connected to the bridge 22″ and the galvanometer 32″ in the manner similar to the connections in the circuit of Figs. 1 and 5. The cable conductor 61, however, connecting to the additional electrode 64, connects to the conductor 23′ and takes the place of the earth connection in Fig. 1 and the cable armor in Fig. 5. The potential impressed by the battery 25″ across the electrodes 64 and 4″ setting up a field therebetween, the strength of which is a function of the resistivity of the formation adjacent those electrodes. In Fig. 6, as in Fig. 5, the galvanometer 32″ is connected directly to an independent ground from conductor 33″.

Various other differences in the detail construction and operation of the circuits described may be made by those skilled in the art without departing from the spirit of the invention, and the invention is to be limited, therefore, only as set forth in the appended claims.

I claim:

1. In earth exploration, the method of determining the nature of the natural fluid contained in a porous formation traversed by a bore hole containing a conductive fluid, which comprises measuring and comparing variations in the electrical resistivity of the formation parallel and close to the bore hole where the formation is permeated with the conductive fluid of the bore hole and parallel to but spaced from the bore hole a distance greater than the distance of penetration of the bore hole fluid from the bore hole into the formation.

2. Apparatus for exploring the formation traversed by a drill hole containing conducting fluid, comprising a cable armored with conducting material on the exterior and containing a pair of insulated conductors, said insulated conductors extending below the lower end of the armor on the cable and terminating in a pair of spaced apart electrodes, means for moving said cable through the drill hole, means for impressing a substantially constant potential between said armor and one of said electrodes, means for measuring variations in resistance between said armor and said one electrode, and means for measuring the potential variations between ground and the other electrode as said cable is moved through the drill hole.

3. Apparatus for exploring the formation traversed by a drill hole filled with conducting fluid, comprising a pair of spaced apart electrodes on an insulated cable adapted to be lowered into the drill hole, said cable containing electrically distinct conductors connecting said two electrodes to the surface, a Wheatstone bridge having a source of constant potential connected across one diagonal thereof and first potential indicating means connected across the other diagonal, in one of the arms of which bridge

is included the resistance between ground and one of said electrodes, and second potential indicating means connected between ground and the other electrode.

4. The method of determining the relative character of fluids in porous strata traversed by a bore hole at points closely adjacent the bore hole and at a predetermined distance away therefrom, respectively, the bore hole containing a relatively conductive drilling fluid, which comprises moving a pair of electrodes which are spaced apart vertically approximately said predetermined distance along said hole through the drilling fluid therein, impressing an electric potential between one of said electrodes and ground at a point substantially distant from said two electrodes, whereby the current through said one electrode is approximately proportional to the formation resistance immediately adjacent said one electrode, measuring the direction of deviation from a selected arbitrary value of said current through said electrode at all levels in said bore hole, and measuring the direction of variation from a selected arbitrary value of the potential difference created by said current between the other of said electrodes and ground at a point substantially distant from said electrodes, at all levels, the relative direction of deviation from said arbitrary values of said current and potential, respectively, at the levels of porous strata affording indications of the relative conductivities of the fluids in said strata at points adjacent and spaced from said bore hole, respectively.

5. The method of determining the character of geological formations penetrated by an uncased bore hole filled with conductive liquid which comprises passing a current between ground and a moving electrode traversing the bore hole whereby an electric field is produced in the formation surrounding the said electrode, measuring the direction and approximate relative magnitude of variations of said current from an arbitrary reference value, said variations resulting from changes in the formation closely adjacent the moving electrode, simultaneously measuring the direction and approximate relative magnitudes of variations from an arbitrary reference value of the potential of said electric field at a moving point in said bore hole spaced a fixed distance from said moving electrode, for comparing and contrasting the variations in said current and said potential respectively, at different levels.

6. Apparatus for exploring the formation traversed by a drill hole containing conductive fluid comprising a cable containing a pair of insulated conductors, said insulated conductors terminating in a pair of spaced apart electrodes, means for moving said cable through the drill hole, means for impressing a substantially constant potential between ground and one of said electrodes, means for measuring variations in the resistance between ground and said one electrode, and means for measuring the potential variations between ground and the other electrode as said cable is moved through the drill hole.

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Dec. 14, 1937. M. M. KINLEY 2,102,080

WELL SURVEYING DEVICE

Filed Dec. 23, 1935 2 Sheets-Sheet 1

Fig. 1.

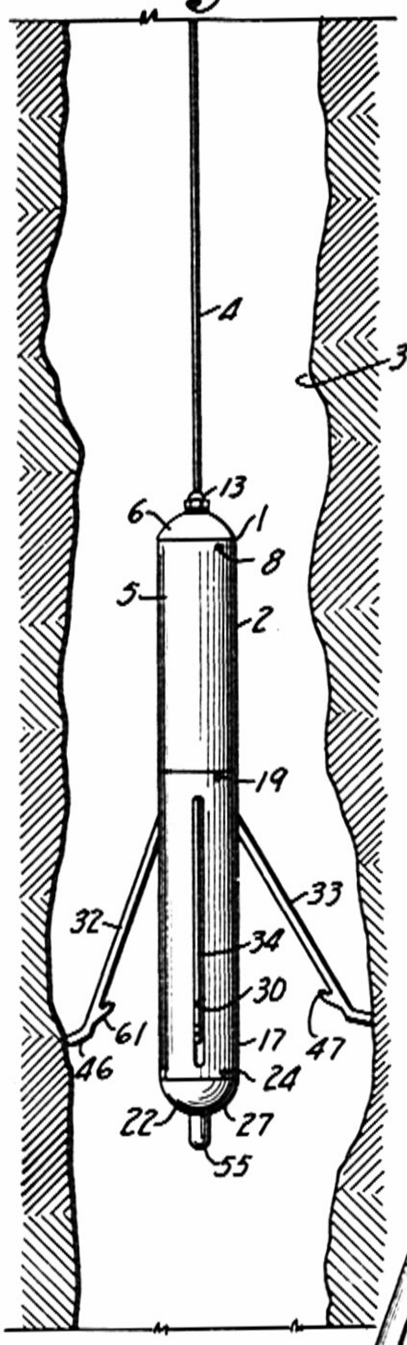


Fig. 2.

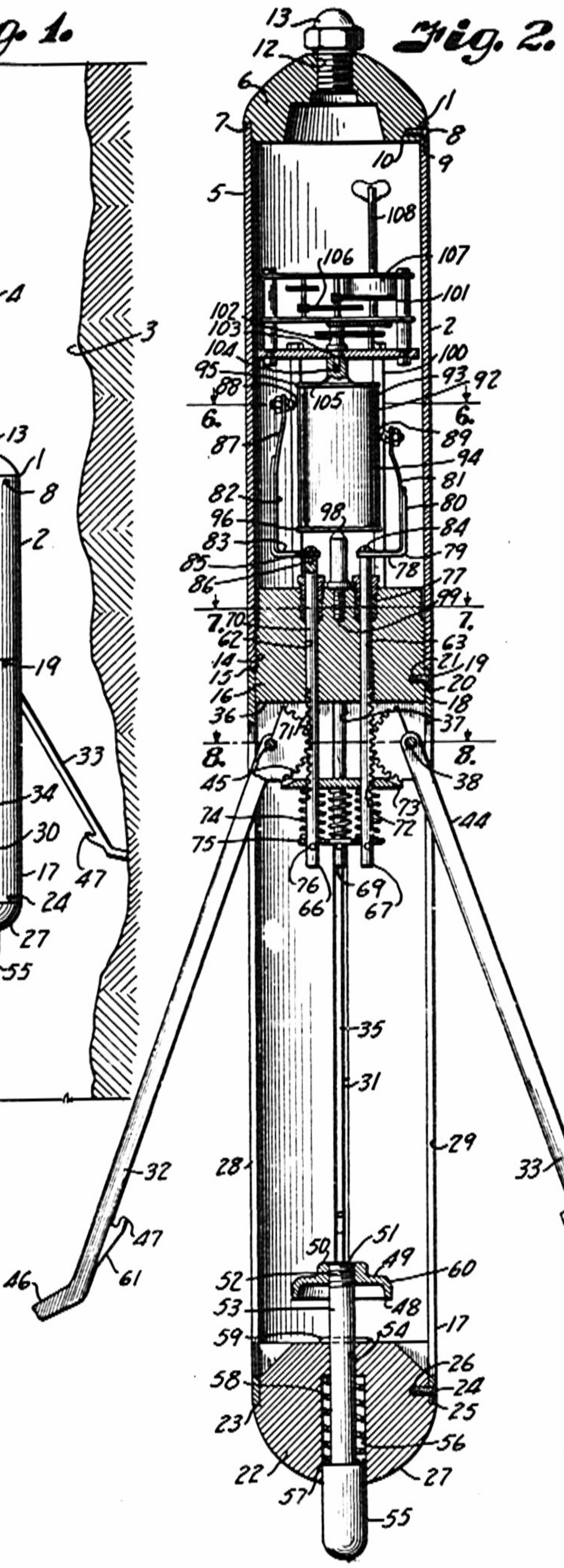
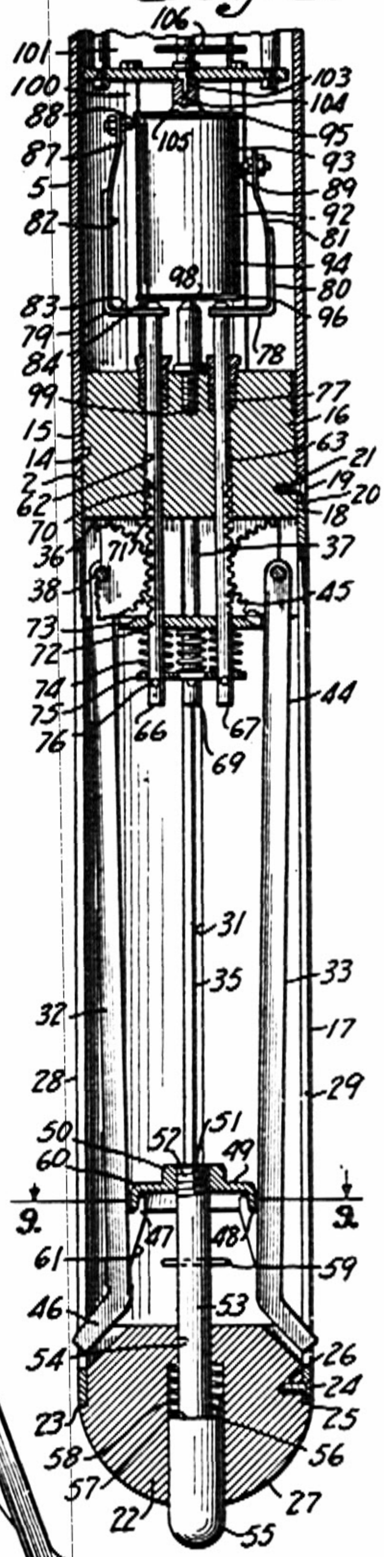


Fig. 3.



INVENTOR

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BY Arthur C. Brown.

ATTORNEY

Dec. 14, 1937. M. M. KINLEY 2,102,080

WELL SURVEYING DEVICE

Filed Dec. 23, 1935 2 Sheets-Sheet 2

Fig. 4.

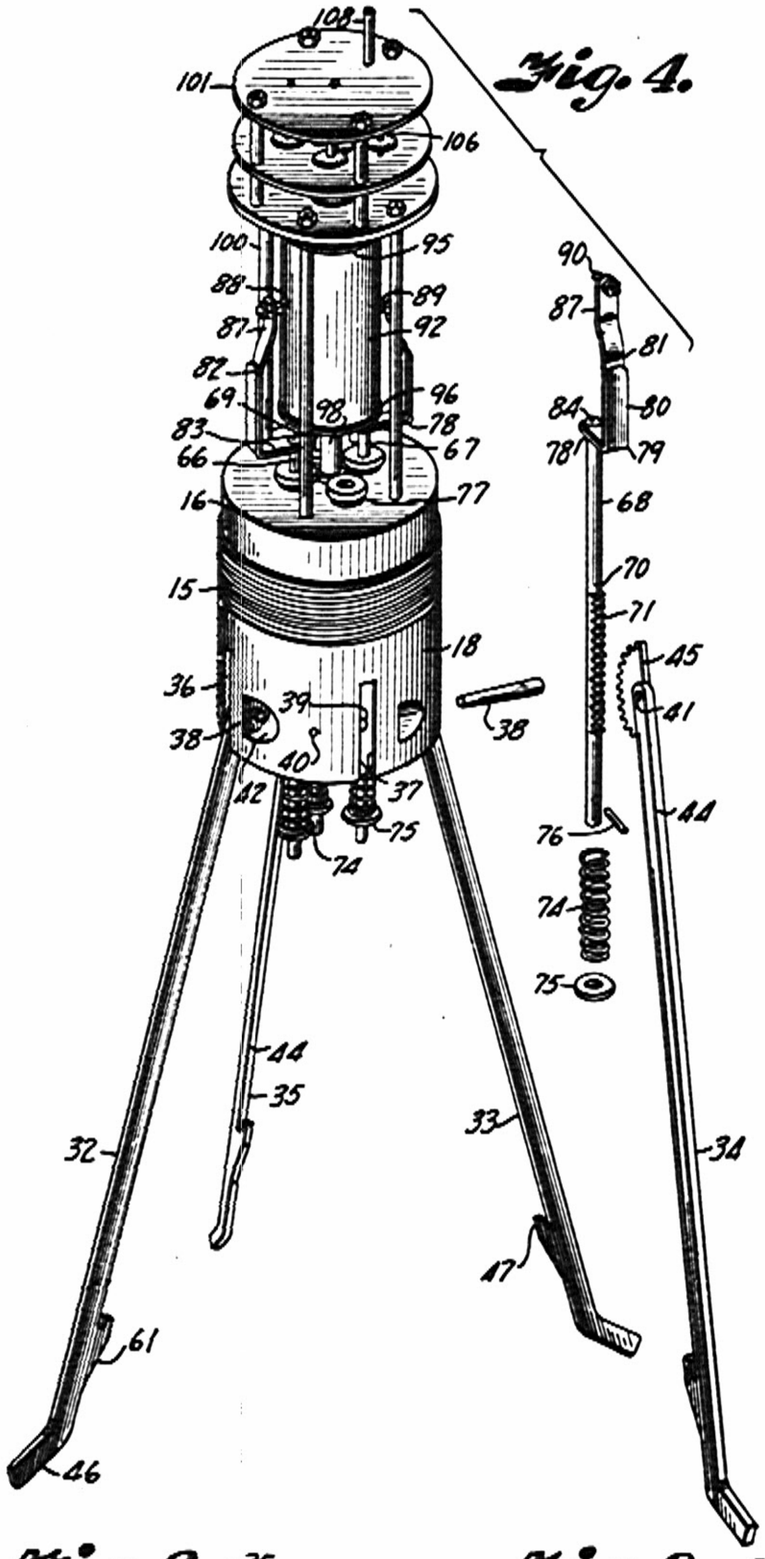


Fig. 5.

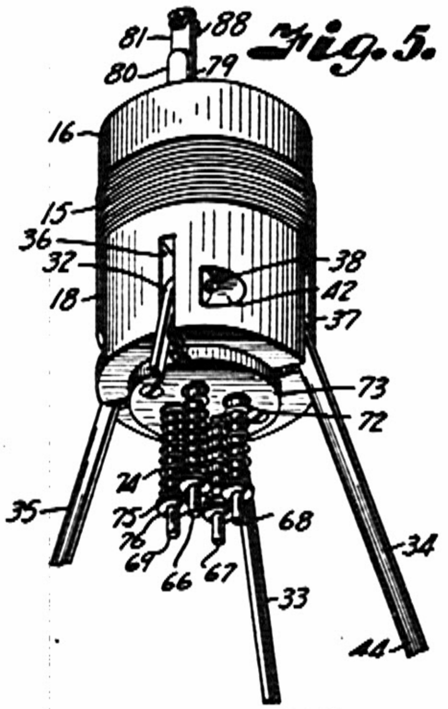


Fig. 6.

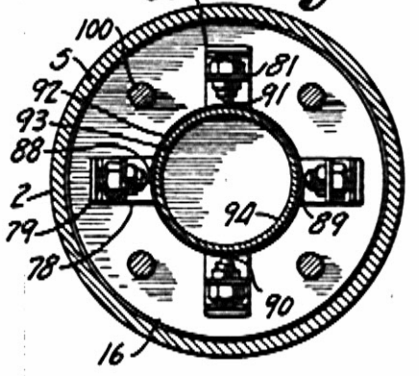


Fig. 7.

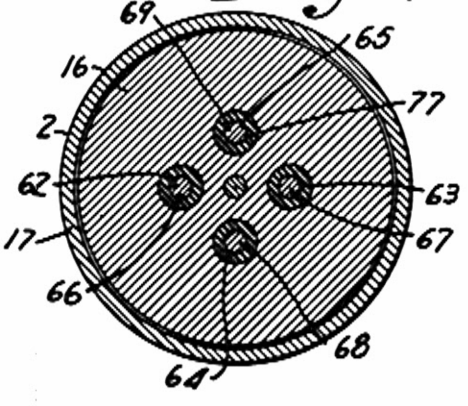


Fig. 8.

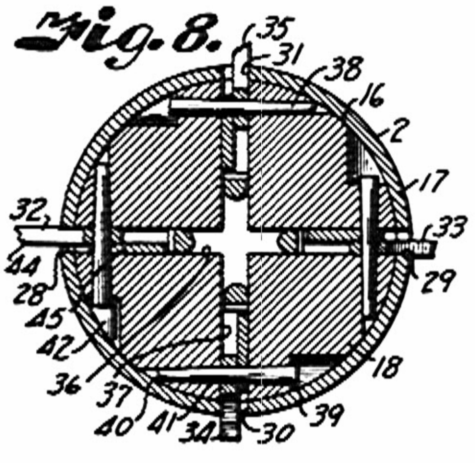
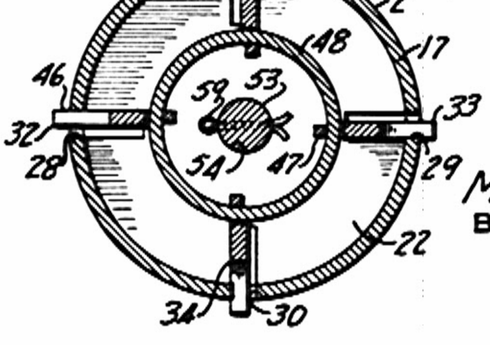


Fig. 9.



INVENTOR

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BY

ATTORNEY

Patented Dec. 14, 1937 **2,102,080**

UNITED STATES PATENT OFFICE

2,102,080

WELL SURVEYING DEVICE

Myron Macy Kinley, Tulsa, Okla.

Application December 23, 1935, Serial No. 55,854

8 Claims. (Cl. 33—174)

This invention relates to a surveying device particularly adapted for use in determining size and shape of a well or similar bore hole, and has for its principal object to provide a device of this character equipped for mechanically producing graphs of the well surfaces.

It is also an important object of the invention to provide for simultaneously recording graphs of opposite transverse diametrical sides of a well, whereby the effective cross sectional area may be ascertained through the portion of the well surveyed. Other objects of the invention are to provide a simple and compact apparatus wherein the working parts are not affected by well fluids or pressures, and to provide means for latching the measuring or calipering mechanism in retractive position when the device is run into the well, and means for automatically releasing the measuring mechanism after the device has reached the bottom of the well.

In accomplishing these and other objects of the invention, as hereinafter pointed out, I have provided improved details of structure, the preferred form of which is illustrated in the accompanying drawings wherein:

Fig. 1 is a cross sectional view through a portion of a bore hole illustrating operation of my improved surveying device for recording any irregular contour of the bore surfaces, such as cavities, projections and the like.

Fig. 2 is an enlarged vertical section through the surveying device particularly illustrating the calipering and recording mechanisms, and showing the caliper or feeler arms in extended position for following the surfaces of a well as the device is being moved through the well.

Fig. 3 is a similar section through the lower portion of the device showing the feeler or caliper arms in retracted and latched position as when the device is being lowered into a well preparatory to the recording operation.

Fig. 4 is a detailed perspective view of the measuring and recording mechanisms removed from the casing, and showing the parts composing one of the measuring mechanisms in disconnected spaced relation.

Fig. 5 is a detail perspective view particularly illustrating the spring elements for retaining the feeler or caliper arms in measuring position.

Fig. 6 is a cross section on the line 6—6 of Fig. 2, particularly illustrating the grouping of the styluses of the respective measuring mechanisms about the recording drum.

Fig. 7 is a cross section on the line 7—7 of Fig. 2, particularly illustrating the method of packing the stylus operating rods to prevent entrance of well fluid into the recording compartment.

Fig. 8 is a cross section on the line 8—8 of Fig. 2, illustrating journal mounting of the feeler arms.

Fig. 9 is a cross section on the line 9—9 of Fig. 3 illustrating the latch mechanism for retaining the feeler arms in contracted position within the casing.

Referring more in detail to the drawings:

1 designates a surveying device constructed in accordance with the present invention and which includes a casing 2 of suitable diameter to be freely lowered and withdrawn from a well hole 3, by means of a cable 4. The casing 2 is shown as including a tubular section 5 closed at its upper end by a plug 6, the plug 6 having an annular shouldered portion 7 inset into the upper end of the section and secured by means of suitable fastening devices, such as screws 8, that are threaded through suitable openings 9 in the tubular sections, and into threaded sockets 10 formed in the plug 6. The upper portion of the plug is of rounded contour 11, and has an internally threaded opening 12 for mounting a line connector or swivel 13 for the line 4. The shouldered joint, between the plug and the upper end of the tubular section, is fluid tight to prevent entrance of well fluids therethrough as the device is lowered into the well. The lower end of the tubular section is internally threaded, as at 14, for engaging the threaded neck 15 of a coupling block 16 that is connected in a lower tubular section 17 of the casing 2.

The lower section 17 conforms in diameter to the upper section 5, and has its upper end fluid-tightly engaging the cylindrical portion 18 of the coupling 16, and is rigidly retained thereon by fastening devices, such as screws 19, threaded through suitable openings 20 in the casing, and into threaded sockets 21 formed in the periphery of the coupling block.

The bottom end of the lower section 17 is closed by a plug 22, having a shouldered portion 23 inset into the end thereof and retained by screws 24 extended through openings 25 and into threaded sockets 26 in the body portion of the plug. The depending end of the plug is rounded, as at 27, to guide the casing over obstructing portions in the surface of the well as the device is being lowered therein, as later described.

The side wall of the section 17 is provided, at opposite transverse diametrical points, with pairs of opposed longitudinal slots 28—29 and 30—31, through which pairs of caliper arms 32—33 and 34—35 are adapted to move into and out of the casing, as now to be described.

Formed in the lower end of the coupling block 16, in alignment with the respective pairs of slots, are transverse grooves 36 and 37 in which the fulcrumed ends of the respective feeler arms are journaled on pins 38. The pins 38 are preferably tapered, as shown in Fig. 8, and extend through aligning tapered openings 39 and 40 adjacent the ends of the slots and through bearing openings

41 in the feeler arms. The portions of the coupling plug adjacent the openings 39 are preferably recessed, as at 42, to facilitate insertion and removal of the pins.

Each feeler arm preferably includes a flat bar 44, having a substantially semi-circular gear segment 45 fixed to the fulcrum end thereof in axial alignment with the bearing opening 41 therein. The opposite end of the bar 44 terminates in an angularly extended foot 46 adapted to contact the inner surface of the bore hole. Formed on the bar 44 above the foot 46 thereof, and extended in the direction of the gear segment 45, is a latch finger 47 adapted to engage under an annular latching flange 48 of a keeper disk 49.

The keeper disk 49 has a central boss 50 provided with an internally threaded opening 51 for engaging the upper threaded end 52 of a plunger 53 that is reciprocably mounted in an axial bore 54 of the bottom plug 22. The lower end of the plunger has a head 55 that is slidable into a counter bore 56 opening upwardly from the rounded end of the plug. Mounted within the counter bore and having one end engaging against a shoulder 57, formed by the head 55, and having its opposite end bearing against the bottom of the counter bore, is a coil spring 58 for normally retaining the head 55 projecting from the block 22, the stem portion of the plunger being provided with a cotter pin 59 to engage against the inner end of the plug for limiting projection of the plunger against action of the spring 58.

When the plunger is in projected position, the latching flange 48 normally lies below the latch fingers 47 when the feeler arms are in retracted position, therefore when the feeler arms are to be latchingly retained within the casing, the plunger is moved upwardly within the casing, against action of the spring, to cause the upper peripheral edge 60 of the latch disk to ride against the cam surfaces 61 of the feeler arms to move them outwardly and permit free passage of the keeper disk. Upon clearance of the latch flange 48 with the latch fingers, contracting pressure applied to the feeler arms will cause them to pass under the flange so that upon release of the plunger 53, the spring 58 will effect movement of the keeper disk into latching engagement with the fingers 47 for holding the lower ends of the feeler arms within the housing.

The feeler arms are, however, constantly urged to projected position so that when released by the keeper disk they will spring outwardly into contact with the wall surfaces of the well as presently described.

Formed in the coupling block, in alignment with each of the transverse grooves, are vertical pairs of bearing openings 62—63 and 64—65 for slidably mounting reciprocatory members 66—67 and 68—69 respectively, each of which includes a cylindrical rod 70 having rack teeth 71 engaging the teeth of the gear segments 45. The lower ends of the shafts project through aligning openings 72 in a disk 73 that engages against the bottom face of the coupling block in bridging relation to the respective grooves. Sleeved on the ends of the rods projecting from the disk 73, are coil springs 74 having one of their ends bearing against the disk, and their opposite ends against washers 75 that are retained on the ends of the rods by transverse pins 76.

It is thus apparent that the springs 74 normally retain the rods at the lower end of their stroke and the feeler arms in their furthest extended position, but as the feeler arms are moved inwardly toward the casing, the tooth connections raise the rods against action of the springs.

The upper ends of the rods project through suitable packing glands 77 sealing the upper ends of the bearing openings, as best shown in Figs. 2 and 7, against entrance of any well fluids that may tend to pass into the recording compartment.

Fixed on the upper end of each shaft is a radially extending leg 78 of an angle shaped bracket 79, having a vertical leg 80 for backing stylus arms 81. The stylus arms 81 are preferably formed of spring material, and have vertical portions 82 fixed to the vertical legs of the brackets, and laterally extending foot portions 83 engaging the upper faces of the radial legs 78. The stylus arms and brackets just described, are fixed to the upper ends of the rods by screws 84 extending through suitable openings 85 in the brackets, and into threaded sockets 86 formed in the ends of the rods. The portions 87 of the respective stylus arms that project above the vertical legs 80 are of differential length, so that the styluses 88, 89, 90 and 91, carried by the respective brackets, are positioned at different levels relatively to the width of a record chart 92 that is applied to a recording drum 93.

The recording drum includes a cylinder 94, having flanged ends 95 and 96 to engage and support the edges of the recording chart 92, and its lower end is mounted on a point bearing 98 that is threaded into the upper end of the coupling block, as indicated at 99. Supported above the recording drum, on posts 100, is a motor 101, having a driving shaft 102 provided with a tongue 103 that engages in a slot 104 in a hub 105, formed on the upper end of the drum. The motor 101 includes suitable gearing and governing mechanism, indicated at 106, that is actuated by spiral spring 107 wound by a suitable key 108.

In preparing the device for use, the upper casing section is removed from the coupling block to expose the motor and recording drum. A chart 92 is then inserted over the drum by raising the styluses from the surface thereof. After the chart has been applied, the spring tension of the stylus arms will return the stylus points into contact with the chart. The feeler arms will then be moved inwardly through their respective slots and temporarily retained by placing the hand over the lower ends of the slots, so as to engage the foot portions thereof and hold them within the casing. The plunger 53 is then moved upwardly against tension of the spring 58, whereupon the keeper disk will cause the arms to move outwardly a sufficient distance to clear the latch engaging flange with the latch fingers. Immediately upon clearance of the disk, and upon release of the plunger, the keeper flange will be moved into engagement with the latch fingers by action of the coil spring, as shown in Fig. 3, to retain the arms in latched position against tension of their springs 74.

When in this position the stylus rods are raised to their upper movement of travel, as shown in Fig. 3. The key 108 is then operated to wind the spring of the motor, after which the upper casing section is reapplied to the coupling block and the device is lowered into the well. When the device reaches the bottom of the well the plunger 53 will engage therewith, but the weight of the device is sufficient to cause the casing to move downwardly over the plunger a sufficient distance to allow release of the latch fingers with the keeper flange. The arms are then released so that the springs 74 cause downward movement of the stylus rods to effect movement of the foot portions of the arms into engagement with the wall of the well.

The device is then lifted from the bottom of the well, whereupon the foot portions of the arms will follow the surface irregularities to effect movement of the styluses relatively to the recording chart, which produces a plurality of graphs thereon in exact conformity to the movement of the respective feeler arms.

Each arm, being adapted to independent movement relative to the other, does not interfere with the record being made by the other arms. The casing will also remain suspended in the axis of the bore hole during the entire upper movement thereof, and the graphs recorded on the chart will show the relative movement of the respective arms to and from the axis of the well hole.

When the device reaches the top of the well, the upper section is again uncoupled from the coupling block to allow removal of the chart from the drum. Upon analysis of the respective graphs that have been recorded on the chart, the relative diameters and shape of the well hole may be readily ascertained.

What I claim and desire to secure by Letters Patent is:

1. In a surveying device for recording surface irregularities of a bore hole, a casing, a plurality of feelers normally yieldingly retained in the casing, independent means for pivotally mounting said feelers for independent movement in the casing in radial planes extending through the axis of the bore hole, means normally retaining the feelers in latched engagement within the casing, means for releasing said feelers for engagement with surface irregularities of the bore hole, and mechanism connected with said feelers for recording variations in movements of the feelers over said surface irregularities.

2. In a measuring and recording device for bore holes, a body, paired independently journaled arms respectively carried at opposite diametrical sides of the body, means for imparting independent movement to said arms radially of the body, means normally latching the arms in the body, means for releasing said arms for contact with the surface of a bore hole, and mechanism in the body and connected with said arms for recording variations in movement of said arms.

3. In a measuring and recording device for bore holes, feeler arms journaled in the device and having independent movement responsive to surface irregularities of a bore hole, a drum rotatably supported in the device for mounting a record chart, a motor for actuating the drum, a stylus connected with each of the feeler arms and contacting the chart for drawing graphs on said chart responsive to movement of said feeler arms, means for latching the feeler arms in retracted position, and means for releasing said latching means to free the feeler arms.

4. In a surveying device for recording the surface irregularities of a bore hole, a body, a plurality of feelers normally yieldingly retained by the body and having latch engaging fingers thereon, a plunger reciprocably mounted in the body, latch means on said plunger for engaging said fingers, a spring normally retaining the plunger with the latch means in engagement with said fingers, and a head on the plunger adapted to be engaged by the bottom of the bore hole for effecting release of the feelers.

5. In a measuring and recording device for bore holes, a casing, feeler arms journaled in the casing and having independent movement responsive to surface irregularities in a bore hole, gear segments connected with the feeler arms, shafts having teeth meshing with the gear segments, means yieldingly urging the shafts in one direction to retain the feeler arms against said surface irregularities, and styluses connected with the respective shafts and adapted for contacting a chart for drawing graphs on said chart responsive to movement of said feeler arms whereby the graphs represent true traces of the irregular surfaces contacted by the respective feeler arms and from which the shape of the bore hole is determined.

6. In a surveying device for recording surface irregularities of a bore hole, a plurality of feeler arms, a casing for the feeler arms, means pivotally connecting one end of the respective arms on opposite diametrical sides of the casing whereby said arms are adapted to swing laterally of the casing to bring the opposite ends of the arms in contact with the surface irregularities of the bore hole, means independently and yieldingly connected with the pivoted ends of said arms for yieldingly retaining said other ends of the arms in contact with the bore hole, and recording mechanism located in the casing and having connection with said independently and yieldingly connected means for independently exhibiting variations in movements of said arms whereby the records made by said recording mechanism are comparable one with the other to determine the shape of the bore hole.

7. In a measuring and recording device for bore holes, a casing including an upper section and a lower slotted section, a coupling block connecting said sections, pairs of feeler arms, means for independently journalling the feeler arms in said block for movement through said slots of the lower section in accordance with surface irregularities in a bore hole and whereby said arms freely follow surface irregularities of the bore hole, a drum rotatably supported in the upper section for mounting a record chart, a motor for actuating the drum, toothed rods slidable through said coupling block, gear segments meshing with the teeth of the rods and having connection with the feeler arms, and a stylus mounted on each rod and contacting the chart for drawing graphs on said chart responsive to movement of said feeler arms.

8. In a measuring and recording device for bore holes, a casing having slots, a plurality of feeler arms having their upper ends journalled in the casing and independently movable through the respective slots so that the opposite ends of said arms are brought into contact with the surface irregularities of a bore hole, means supporting a record chart in the casing, means for progressively moving the chart, and styluses operatively connected with the respective feeler arms for contacting areas of the chart for drawing independent graphs on said chart responsive to movement of said feeler arms from which the size and shape of the bore hole is determined.

MYRON MACY KINLEY.

Aug. 1, 1939. C. B. BAZZONI ET AL **2,167,630**

ELECTRICAL PROSPECTING METHOD AND APPARATUS

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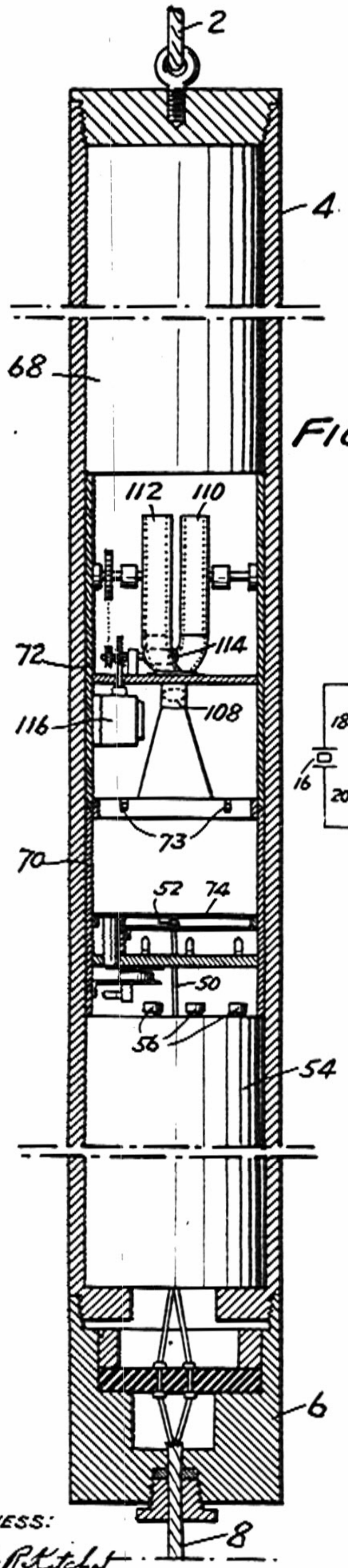

FIG. 1A.

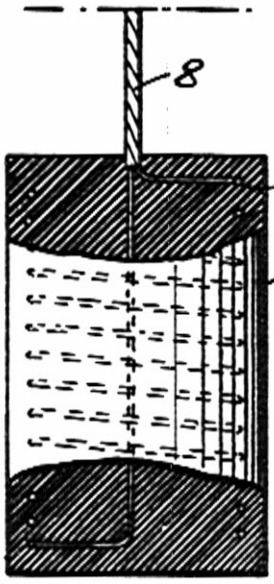

FIG. 1B.

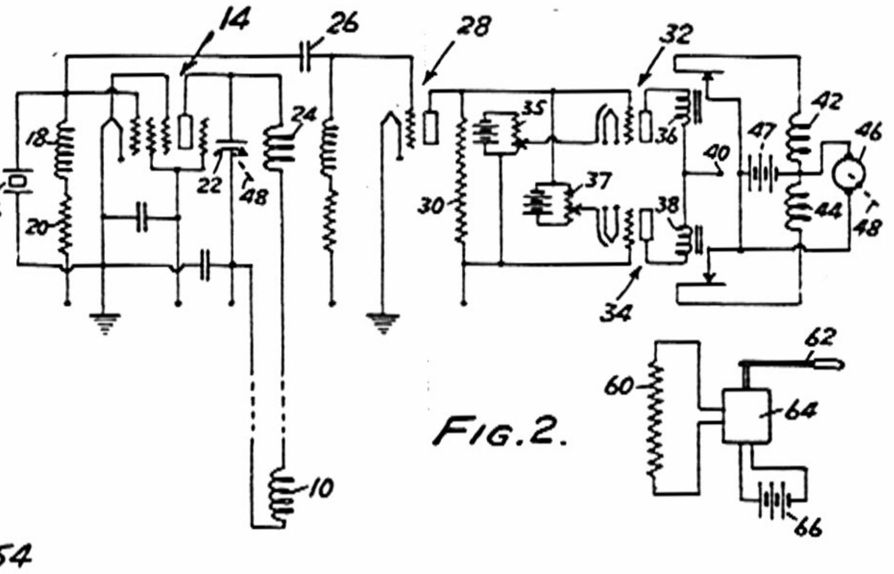

FIG. 2.

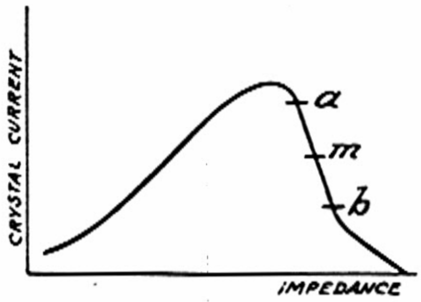

FIG. 3.

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ELECTRICAL PROSPECTING METHOD AND APPARATUS

Filed April 2, 1936 3 Sheets-Sheet 2

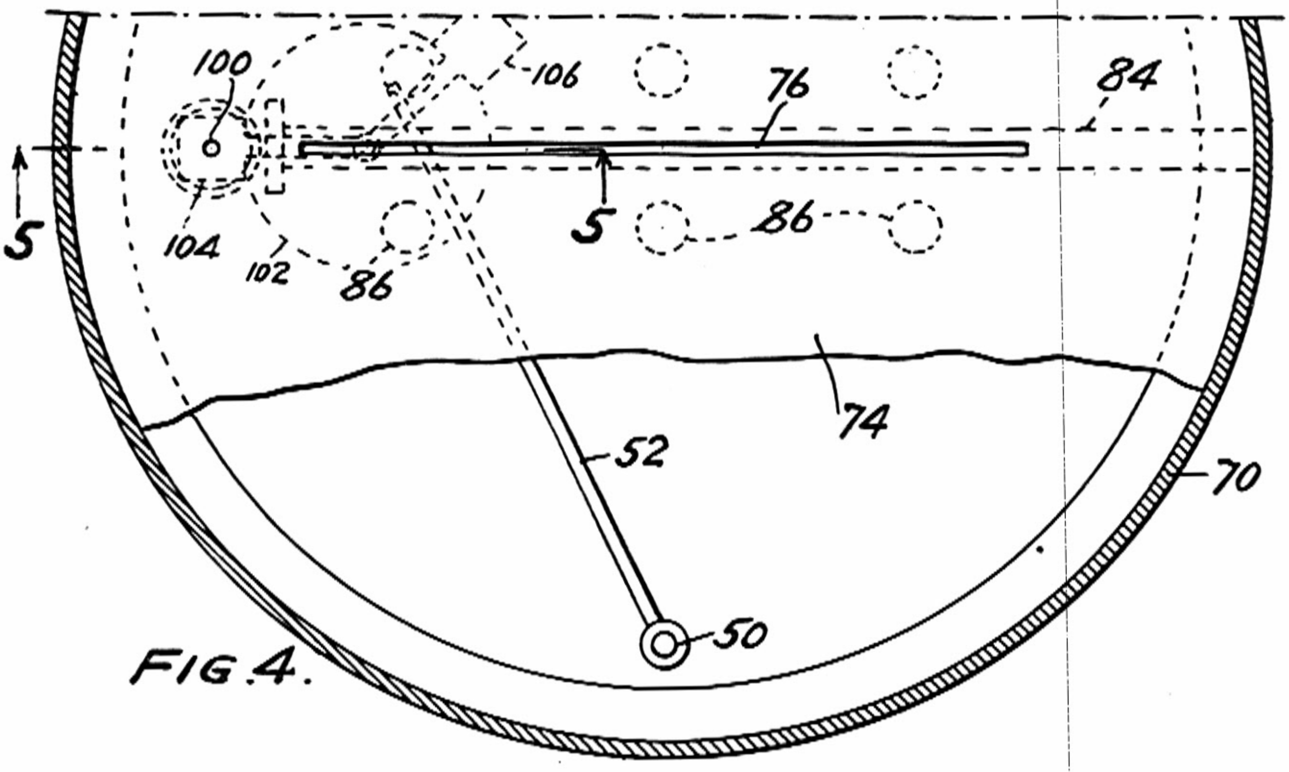

FIG. 4.

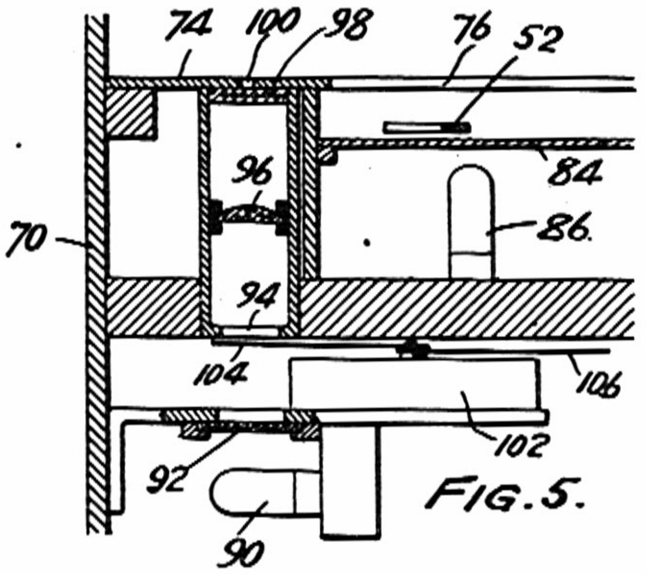

FIG. 5.

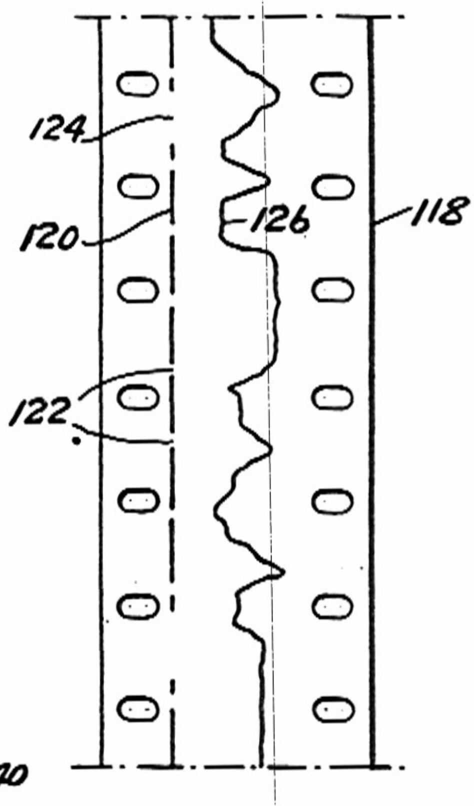

FIG. 6.

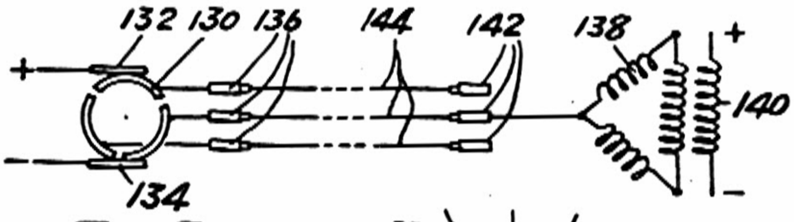

FIG. 7.

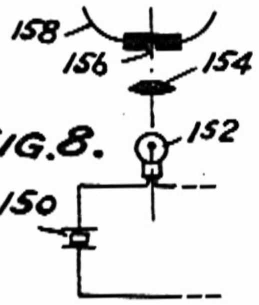

FIG. 8.

WITNESS:
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Aug. 1, 1939. C. B. BAZZONI ET AL **2,167,630**

ELECTRICAL PROSPECTING METHOD AND APPARATUS

Filed April 2, 1936 3 Sheets-Sheet 3

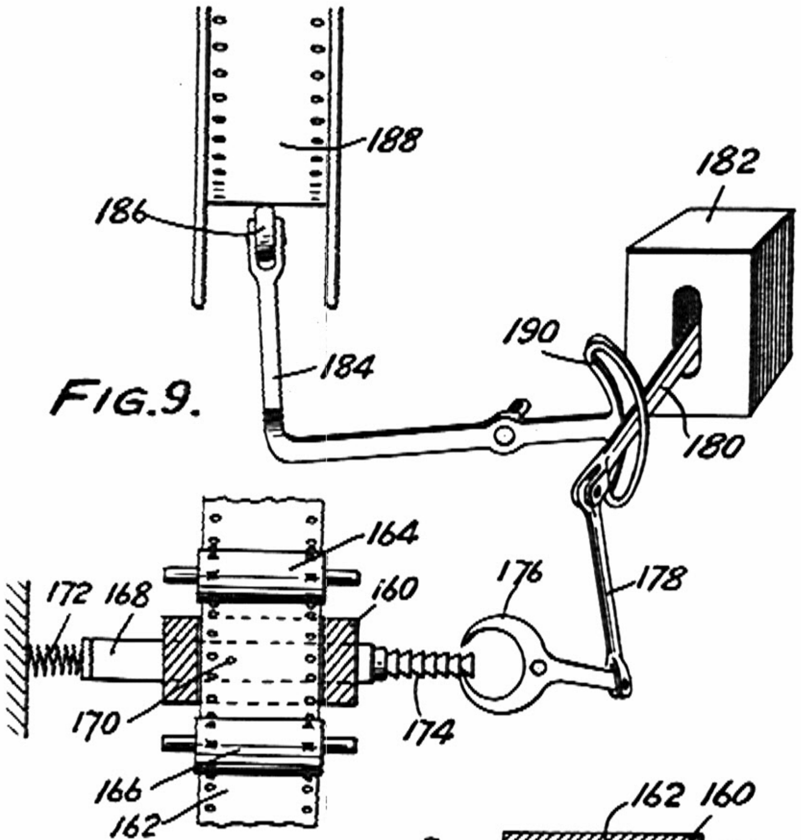

FIG. 9.

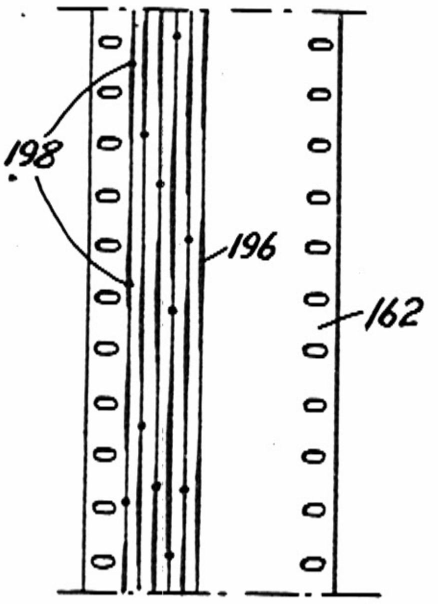

FIG. 11.

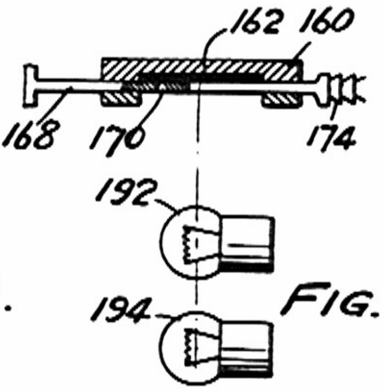

FIG. 10.

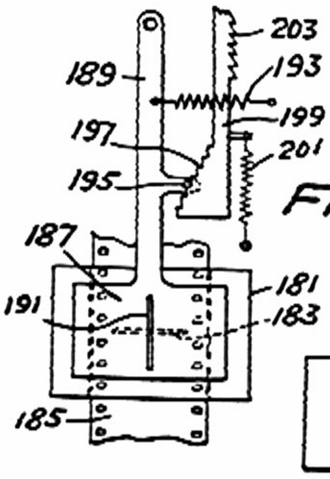

FIG. 12.

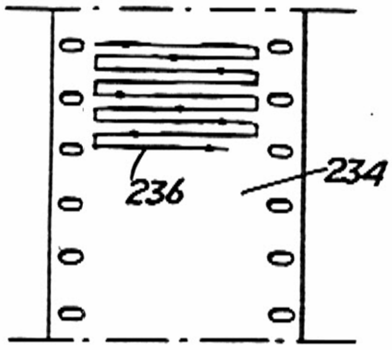

FIG. 14.

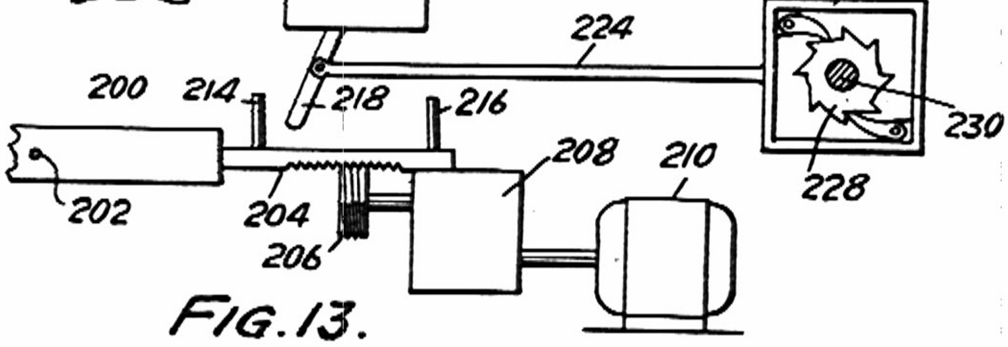

FIG. 13.

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UNITED STATES PATENT OFFICE

2,167,630

ELECTRICAL PROSPECTING METHOD AND APPARATUS

Charles B. Bazzoni, Wallingford, and Joseph Razek, Llanerch, Pa., assignors to Sperry-Sun Well Surveying Company, Philadelphia, Pa., a corporation of Delaware

Application April 2, 1936, Serial No. 72,246

14 Claims. (Cl. 175—182)

This invention relates to geophysical prospecting and more particularly, by so-called electrical coring, to the determination of the nature and boundaries of formations traversed by bore holes.

The various formations which make up the portion of the crust of the earth which has been penetrated by bore holes vary quite considerably in their specific resistivities and dielectric constants. In view of this, proposals have been made to determine the location and nature of subterranean formations by producing high frequency electromagnetic fields in such fashions that they will be substantially affected by the presence of the formations under investigation. If a source giving rise to a high frequency electromagnetic field is located at or adjacent to the surface of the earth, and if the field is given the necessary spatial disposition, its characteristics measured by its reaction on the source or, alternatively, by suitable detectors located at different distances from the source, will give information from which deductions may be made as to the nature and location of subterranean formations.

It was proposed in Löwy Patent No. 1,092,065, dated March 21, 1914, to determine the nature and location of subterranean formations by producing fields of this type in bore holes or mines. In the case of a mine, the method described in that patent could be carried out by having an observer operate the apparatus directly at the source of the high frequency field. In using the method in a bore hole, however, it would be necessary to supply some telemetering apparatus to carry the results produced at the location of the source to the surface in order to be observable.

The general object of the present invention is to provide a method and apparatus whereby records are made in a bore hole at a short distance from an electromagnetic field the variations of which, due to the presence of different formations in the vicinity of the source, are to be measured. More specifically, in accordance with the invention there is generated a high frequency electromagnetic field within a bore hole by means of an exploring unit which may be lowered into the hole by means of a wire line or drill stem. The apparatus includes a suitable exciting element which may take the form of an antenna or a coil, either of which is arranged so that a substantial part of its resulting electromagnetic field penetrates the formations through which the bore hole passes. In the case of an antenna, the dielectric constants and resistivities of the surrounding earth will vary its impedance and hence its reaction upon the generating circuit of which it forms a part. The major effects in the case of an antenna will be due to the different dielectric constants of the formations which are encountered. Likewise, if a coil is used it will have an effective impedance depending primarily both upon the specific resistivities and dielectric constants of the formations lying within the portion of its field adjacent the coil. The varying impedance thus resulting as the apparatus traverses the bore hole will show itself in the generating circuit.

Specifically, in accordance with the present invention there is provided a generating circuit having the characteristic of operating at a fixed or substantially fixed frequency despite substantial variations in the impedance of an exploring coil or antenna which establishes an electromagnetic field in the strata surrounding the hole. When a circuit of this sort is used, for example, when crystal control is utilized to maintain the frequency substantially constant, the variation of impedance of the exploratory device produces substantial variations in the currents and voltages existing in the generating circuit. Specifically when crystal-control is used, adjustment may be made so that an extremely slight change in impedance of the exploratory elements will result in a quite considerable change in the currents and voltages existing in the generator, for example, in the crystal current.

The very considerable sensitivity to minor changes in impedance are normally accompanied by either cessation of oscillations on the one hand, or operation within a more stable and quite insensitive region on the other. In order to maintain the sensitivity for very considerable changes in the electrical characteristics of the strata which are encountered, provision is made for automatically adjusting the generating circuit to secure substantially constant impedance conditions in the circuit involving the exploratory element. Specifically, this is accomplished by providing a tuning element such as a condenser in the exploratory circuit, which condenser is arranged to be driven by a reversible motor controlled by changes in the generating circuit. If, for example, the motor is controlled by the crystal current, the arrangement may be so made as to maintain the crystal current substantially constant so that operation is maintained in a given region of a crystal current-impedance characteristic where the sensitivity is greatest. Obviously, in such case indications of the nature of the strata are obtained by observing the variations with depth of the stable position of the tuning element.

It is obvious that this characteristic of operation involving the maintenance of a substantially constant condition may be used with other than crystal control. This will become clear hereafter. While preferably records are made in the bore in order to avoid the necessity for providing insulated cables running to the surface so that the apparatus may not only be lowered on an ordinary wire line, but also, if desired, on a drill stem through which it is quite difficult to conduct current unless elaborate special drill stem sections are used, it is also possible to telemeter to the surface the positions of a tuning element such as that mentioned. Such telemetering also forms one phase of the invention, the telemetering, under some conditions, being useful even in an apparatus which makes the records within the bore hole, since it may be inconvenient to arrange the apparatus in some instances so that direct recording of the position of a tuned element is possible.

Even if automatic adjustment is not used to maintain some operating condition constant, a crystal circuit, or some other critically resonant circuit, is very well adapted to give quite sensitive responses if adjustments to increase stability are made. In such cases photographic recording is quite easily accomplished in accordance with a further modification of the invention, this type of recording being of even more general application. The photographic record, after development, may take the form of a track, or plurality of tracks, of variable density which may be scanned by a photoelectric apparatus to give a second record on a paper strip or the like. One advantage of this is the comparative simplicity of the apparatus in the bore hole; another is the possibility of providing a record many times the length of the film. The latter advantage is a very substantial one since the restricted space available limits the amount of film which may be carried in the instrument.

The various objects of the invention, including not only the broad ones indicated above but more specific ones directed primarily to details of construction will be apparent from the following description read in conjunction with the accompanying drawings, in which:

Fig. 1A is a vertical section showing in a diagrammatic form a protective casing and various elements located therein providing a preferred form of apparatus in accordance with the invention;

Fig. 1B is a continuation of the lower portion of Fig. 1A showing an exploring element;

Fig. 2 is a wiring diagram showing electrical connections involved in a preferred form of the apparatus;

Fig. 3 is a diagram showing a typical crystal current-impedance characteristic of an apparatus of the type shown in Fig. 2;

Fig. 4 is a transverse section showing the instruments which are photographed to produce the records;

Fig. 5 is a vertical section taken on the plane indicated at 5—5 in Fig. 4;

Fig. 6 is a fragmentary view showing the nature of the photographic record produced by the apparatus;

Fig. 7 is a wiring diagram showing a simple direct current operated telemetering apparatus which may be used in connection with the invention;

Fig. 8 is a diagrammatic view illustrating a modified recording arrangement in accordance with the invention;

Fig. 9 is a diagrammatic view illustrating an arrangement whereby there may be produced on a film a record having many times the length of the film;

Fig. 10 is a diagrammatic sectional view showing the same apparatus;

Fig. 11 is a fragmentary view showing the type of record made upon a film by an apparatus of Figs. 9 and 10;

Fig. 12 is a diagrammatic view of a modified arrangement designed to produce a record similar to that produced by the mechanism of Fig. 9;

Fig. 13 is a further modification accomplishing the purpose of providing a very long record upon a limited length of film; and

Fig. 14 is a fragmentary view of a record produced by the apparatus of Fig. 13.

Referring first to Figs. 1A and 1B, there is shown as supported by a cable **2** an exploring unit including a protective casing **4** capable of withstanding the pressures which would be encountered in the deepest mud-filled bore hole in which the apparatus is to be used. The bottom of this casing is closed by a plug **6** which is packed in such fashion as to permit the passage of an armored two-wire cable **8** the lower end of which is connected to an insulating support **12** within which there is molded a coil **10** the ends of which are connected to the two wires extending through the cable. The support may take the form indicated or may otherwise carry an exploring coil which is of the largest diameter which may be conveniently used in the bore hole so that a considerable proportion of the lines of force of its field penetrate the formations. Its axial length should be small in order to increase the possibility of detecting very shallow formations. The spacing of the coil **10** from the casing **4** need not be very great but should be such that the metallic casing does not provide a secondary having any appreciable effect.

Referring now to the generating circuit indicated in Fig. 2, there is provided a crystal-controlled oscillator including a pentode tube indicated at **14** in the control grid circuit of which there is inserted a crystal **16**. This oscillator is of conventional type, a proper bias being applied to the control grid through the choke **18** and resistance **20**. The plate circuit is tuned by the condenser **22** and the exploratory coil **10**, with which there may or may not be associated a further coil **24** located within the casing **4**. A crystal controlled oscillator of this type will produce oscillations so long as the circuit is approximately at resonance at the fundamental frequency of the crystal. In the vicinity of the resonance condition the crystal current will vary with the impedance of the tuned circuit in a fashion such as indicated in Fig. 3. When the resonance condition exists, the crystal current will be a maximum. On one side of this, as indicated at the right hand portion of the graph in Fig. 3, the crystal current sharply drops with a change in impedance to a point where cessation of oscillations occurs. If operation is effected between *a* and *b* in Fig. 3, it will be seen that a very slight change in impedance will result in a very considerable change in the crystal current. Desirably, therefore, operating conditions should be such that the normal condition of operation is somewhere between *a* and *b* at, say, *m*.

The setup is preferably such that the impedance of the turned circuit changes very considerably more than the change from *a* to *b* as different formations are encountered within the well. Operation in the desired part of the characteristic must be maintained, therefore, by automatic tuning of the oscillatory circuit. This may be readily effected by the control arrangements illustrated in Fig. 2.

The control grid of the oscillator is connected through a condenser **26** to the grid of a detector tube **28**, the plate of which is provided with a resistance load indicated at **30**. Conditions of operation are so chosen that a maximum change in current through the resistance **30** is secured for a given variation in the crystal current. Connected across this resistance **30** as illustrated in the diagram are tubes **32** and **34**, the cathodes of which are brought to proper potentials relative to the grids by potentiometers **35** and **37**, cross-connected as indicated. There are symmetrically connected in the plate circuits relays **36** and **38** which are joined at their connection to the high voltage supply at **40**. It will be clear that the relays may be so adjusted that they are selectively closed depending upon the magnitude of the current through the resistance **30**, one or the other alone being closed whenever the current varies by some predetermined amount above or below a mean value. The two relays are connected to the outer ends of two portions **42** and **44** of a center tapped shunt field coil of a D. C. motor **46** which is energized by a battery **47**. If both the relays are closed or both open under a normal condition, the field coil will be deenergized either due to no current flow or symmetrical currents in its two halves. Accordingly no torque will be produced by the motor **46**. On the other hand, if either one of the relays is closed, the motor will operate in a corresponding direction. The motor is connected through suitable reduction gearing to the condenser **22** so as to drive it slowly forwardly or backwardly. These connections are diagrammatically indicated at **48**.

It will be obvious from the above that by proper adjustments of the various portions of the circuit the impedance of the parallel circuit in the oscillator will be so maintained as to keep the crystal current substantially constant, deviation from the mean point *m* of the characteristic being automatically corrected by adjustment of the condenser **22**. It is found that a circuit operating as above is very sensitive and that no difficulty is experienced in maintaining operation at all times on the desired portion of the characteristic.

It is obvious that if the parallel impedance is so maintained as to keep the crystal current substantially constant the change in impedance of the coil **10** due to different formations which are encountered may be measured by the changes in the position of the condenser **22** in order to maintain the crystal current constant. In accordance with the preferred form of the invention, the position of the tuning condenser is recorded. This may be accomplished by extending the shaft of the tuning condenser indicated at **50** exteriorly of the oscillator assembly and providing it with a pointer such as **52**, the position of which may be photographed.

The oscillator and other electrical apparatus may be enclosed in a unit such as indicated at **54**, exterior adjustments being accomplished through knobs **56**. The oscillator itself may be heat insulated if great accuracy is required. The crystal may so cut as to show practically no change in fundamental frequency with large changes of temperature. However, the temperature changes encountered in a bore hole may be such that the various impedances in the plate circuit may change considerably. Consequently, it is desirable to enclose the oscillator in a heat insulated casing containing a heating coil **60** connected through a relay **64** to a source of heating current **66** such as a storage battery, the relay being under control of a thermostat element **62** which is located within the insulating casing. The thermostat must, of course, be set so as to hold the oscillator at a temperature substantially higher than the highest which may be expected to be encountered in the bore hole. The heat insulation should not be perfect but should be such that outward flow of heat may take place to such extent that the heat generated in the oscillator circuit will not raise the temperature to that which is thermostatically set so long as there is a substantial gradient between the thermostatically controlled temperature and that of the bore hole. Indicating means may be provided to show when the temperature in the bore hole rises substantially to that maintained by the thermostat in order to give an indication that the impedance within the insulated casing may have varied. Besides the impedances within the casing, it is desirable to so construct the coil **10** and its support that a relatively slight temperature coefficient exists for the impedance. However, if this is not done, the result will be only a gradual drift of the record which is of little importance inasmuch as sharp breaks in the record are of primary interest. Because of this latter consideration, it is feasible to eliminate thermostatic control altogether where qualitative indications are primarily desired. Thermostatic control is desirable, however, where in and out runs are made for checking purposes. Because of the fact that time is consumed in heat transfer the temperatures going in will not correspond to those going out at the same depths.

The batteries for the operation of the device are conveniently located in a separate chamber indicated at **68** at the upper portion of the protective casing **4**. Beneath this there are located two auxiliary casings **70** and **72** lined up relatively to each other, for example, by pin and slot connections indicated at **73**, so that apparatus carried by the former may be located in proper position to be photographed by an automatic camera carried by the latter. The apparatus contained in the chamber **70** is shown in detail in Figs. 4 and 5. The chamber is provided with a transverse plate **74** which closes the chamber **70** except for a narrow slit **76** and a small opening **100** located as shown in the figures, the width of the slit being somewhat exaggerated therein. The pointer **52** connected to the condenser shaft **50** is located at one side of the slit so as to intercept the slit as it swings. Extending lengthwise beneath the slit **76** there is a strip **84**, the upper face of which is blackened, as is also the upper face of the plate **74**, to prevent reflections which might fog the film. The upper surface of the pointer **52** is whitened so as to reflect light, while the lower surface of the plate **74** is silvered or whitened so as to reflect light downwardly upon the pointer **62**.

In order to give time measurements from which the depths may be ascertained, the lamp **90** is provided to illuminate ground glass target

92 located beneath an opening 94 which permits light to pass from the target 92 to a lens 96 which concentrates it upon a ground glass 98 located beneath a small hole 100. The illumination passing through the opening 100 is periodically interrupted by the hands 104 and 106 of a watch 102 which have enlarged outer ends, as indicated most clearly in Fig. 4, serving to completely cover at periodic intervals the opening 94. The hands driven by the watch mechanism may, for example, be so arranged that one makes, say, one revolution in a half minute, and the other one revolution in five minutes. In such case there will be a short interruption of the light at half-minute intervals while at five minute intervals longer interruptions will occur due to the slower passage of the five-minute hand. Located in the chamber 72 is a camera mechanism comprising a lens 108 projecting an image of the slit 76 and hole 100 upon motion picture film which passes from a supply reel 110 to a receiving reel 112 across the field of the lens in a direction transverse to the slit 76. This film is continuously driven by a motor 116 through reduction gearing and a sprocket wheel 114. If the apparatus is to be lowered on a wire line, the motor 116 is arranged to run continuously so that the film advances at a slow rate of speed, which rate, however, will be sufficient when the rapidity of lowering of the apparatus is considered, to clearly distinguish formations which would be of interest.

The type of record produced by the apparatus is illustrated in Fig. 6. There would be two traces on the film produced by the illuminated opening 100 and the pointer 52. These records are indicated respectively at 120 and 126. The first record as indicated above will consist of an interrupted straight line running the length of the film and provided with a series of short interruptions 122, every tenth one of which 124 will be substantially longer so as to facilitate counting in the ultimate interpretation. The record of the pointer 52 will be a wavy line 126 which will be indicative of the varying specific resistivities and dielectric constants of the encountered formations which change the impedance of the coil 10.

Numerous variations may be made while utilizing the principle of this invention. One modification which has been mentioned above involves the use of an antenna as the exploring element instead of a coil. The antenna in such case may be used to form part of the capacity in the oscillator tank circuit in various ways. The condenser formed by the antenna may be either in series or parallel with an adjustable condenser such as 22 or, instead of providing an adjustable condenser, a continuously varying inductance may be provided by arranging two coils rotatable with respect to each other by means of a controlling motor such as 46. An antenna, however, is not so satisfactory as a coil, since its length must necessarily be such as to make it impossible to detect thin formations.

If a crystal oscillator is used, changes other than those of the crystal current may be used for controlling purposes. In a circuit such as that illustrated, for example, not only does the crystal current change with change of impedance in the plate circuit but the currents and voltages in the other parts of the circuit also vary quite considerably. Advantage may be taken of any such variations for producing control of the type illustrated.

While a crystal provides the simplest arrangement for fixing some condition of the oscillator with respect to which changes may be produced by varying formations to effect substantial modifications of circuit conditions, the crystal obviously may be replaced by a resonant circuit so that the result is a tuned-plate, tuned-grid type of circuit. A somewhat similar resonance curve is produced in that case and again it is possible to vary some impedance in the circuit to maintain operations along a given portion of a characteristic such as that of Fig. 3.

In order to avoid surface connection, it is preferable to make records in a fashion such as that described above, the record then taking the form, for example, of a photographic picture of the movements of a pointer such as 52. In some cases, however, it may be desirable to provide a telemetering apparatus to transfer the automatic adjustments to the surface. Fig. 7 illustrates a simple device which is direct current operated and which may be used for such purpose. A three-part commutator 130, on which bear brushes 132 and 134 connected to the terminals of a battery, is mounted upon the shaft of the motor 46 which also carries slip rings 136 connected respectively to the segments of the commutator. At some remote location where the records are to be produced a motor is provided which may comprise three poles wound in delta, as indicated at 138, there being provided, say, two opposed field poles having a winding 140 which is maintained energized by a battery. The three corners of the delta connection are electrically connected to slip rings 142. Brushes bearing on the slip rings 136 and 142 are connected by three wires 144 which may run through a cable from the instrument to the surface. It will be obvious that any rotations of the motor 46 will be imparted (to an accuracy of a third of a revolution) to the armature 138 through such arrangement. This armature, through suitable reduction gearing, may drive a pointer which may be observed visually or photographed as indicated above. An arrangement of this sort may also be used where it is inconvenient to run a shaft 50 directly from a variable impedance such as condenser 22 to provide recording as in Fig. 1A. The telemetering arrangement illustrated in Fig. 7 is described in the patent to Ford, 1,153,210, dated September 14, 1915.

Inasmuch as in the preferred form of the apparatus a motor is provided to adjust an impedance, the adjustments of which are recorded, there is available for recording purposes a substantial amount of power so that instead of having recourse to photographic recording, it is possible to move a stylus transversely of a moving strip of paper or the like to produce a record. In such case time marks may be made by a suitable clockwork mechanism capable of providing marks on the edge of the paper strip.

The apparatus may be substantially simplified with, however, a loss in sensitivity and range, by merely providing and photographing a meter, or some other instrument sensitive to current or voltage changes, located in some portion of the oscillator circuit in which substantial current or voltage changes take place as the impedance in the plate circuit varies. Alternatively the meter may be operated through a relay in the nature of a vacuum tube voltmeter responsible to voltage changes in the circuit. In any such case operation is preferably maintained along a limited portion of a characteristic such as between

A and B of Fig. 3. To insure that the limits are not exceeded, the sensitivity of the exploring element must be reduced. For example, in such case an exploring coil such as **10** might provide only a relatively small portion of the inductance in a tuned circuit, the major portion being provided by an internal coil such as **24**.

It is desirable, in an apparatus of this type, to have the mechanism within the bore hole as simple as possible in order to avoid substantial loss in case of an accident which might destroy or prevent the recovery of the apparatus such as, for example, the collapse of the walls of the bore hole or other causes. The type of arrangement just mentioned may be put in the quite simple form indicated in Fig. 8. In this figure, **150** represents the crystal of a crystal-controlled oscillator such as that of Fig. 2, in which, however, the coupling with the exploratory element is such that the operation is continuously along a portion such as A—B of a characteristic of the type in Fig. 3 without the necessity for automatic control. The crystal may be replaced by some other resonant circuit. A lamp **152** in the crystal circuit will then be variably illuminated, depending upon the crystal current. The light from the filament of such lamp may fall directly upon or may be concentrated as by a lens **154** upon a hole or slit **156** transversely to which there moves continuously a film such as **158**. A record will then be made on the film resembling a motion picture sound track, namely, consisting, in the developed film, of lighter and darker areas which will correspond to the electrical properties of the formations which are penetrated. In view of the fact that the width of the film is of no moment, it may be quite narrow, for example, of the present commercial 8 mm. type. If a slit is used, time marks may be readily provided by causing watch hands such as **104** and **106** of Fig. 5 to periodically intercept one end of the slit.

The record thus made may not be interpretable directly. However, by providing an apparatus on the surface through which the film may be moved to intercept a light beam which is directed upon a photoelectric cell of suitable character, the responses of the cell may be made to operate recording apparatus which will result in a graph resembling that of Fig. 6. In order to record the time marks indicated above it would, of course, be necessary to provide separate portions of a single beam or a plurality of beams acting upon individual light responsive cells. The apparatus within the bore hole in this case will be comparatively inexpensive.

In the above apparatus it is desirable to provide a ballast tube in series with tube **152** in order to limit the currents thereto and thus prevent it from burning out. In addition, a photoelectric or other monitor may be provided to open circuit connections in case oscillations cease, in order to prevent damage to the oscillator circuit by the flow of excessive plate current. A consideration which must be taken into account in any appartus automatically recording within a bore hole is the limitation due to the available space on the film which may be carried in the apparatus. While, in accordance with the above, the film may be moved quite slowly, nevertheless in surveying a very deep well with the object of determining thin strata it is necessary that such a speed of movement be imparted to the film that a single film will be insufficient if the record which is made is only of the length of the film. Apparatus for changing films or for selectively recording on different films are mechanically complicated. It is a further object of the present invention, therefore, to provide means whereby the total length of record which is made may be many times the actual length of film.

In accordance with the modification illustrated in Figs. 9, 10 and 11, the type of recording indicated in Fig. 8 is used. In other words, a lamp is used to produce a record, the lamp being variably illuminated depending upon the high frequency currents flowing therethrough. Instead of providing a record of the full film width as in Fig. 8, however, quite narrow lines of varying density are produced upon the film.

A guide **160** is provided for the film **162**, the film being moved by means of sprocket wheels **164** and **166**, two of which are provided in order that the film may be properly moved in both directions, these sprockets being geared together. Additionally, there are connected to the sprocket driving means devices for rotating supply and take-up reels.

Below the film there is provided a transverse slide **168** which is provided with a minute opening **170** providing the only communication between the film and the space below the same. The slide **168** is urged toward the right by a spring **172** and is provided with an escapement arrangement indicated at **174** and **176** to control its movements towards the right. The member **176** of the escapment is connected by a link **178** to the operating lever **180** of a snap switch **182**. A lever **174** carries a follower roller **186** which bears upon the film **188** on one of the reels, which act successively as supply and take-up reels. The end of this lever is provided with an arcuate slot **190**.

A lamp **192** below the slide **168** corresponds with the lamp **152** of Fig. 8, namely, it is variably illuminated by current flowing in the oscillator circuit. An additional lamp **194** is provided, being arranged to flash brightly at suitable intervals by an accurate clockwork controlled switch.

In the operation of this device, the film **162** will be first moved continuously at a slow rate in one direction. As the movement takes place, a line of the film is continuously exposed to the illumination of the lamp **192** through the opening **170**. Upon development, consequently, there will be found a line of variable density such as **196**, the density depending upon the current flowing through the lamp. At intervals the lamp **194** is brightly illuminated for very short times and consequently there are produced spots **198** of very much increased density serving as time marks. If the roller **186** is assumed to be riding upon the reel acting at this time as a supply reel, it will ultimately cause a movement of the lever **180** of the snap switch **182** to such extent as to cause it to snap to its opposite position, this action occurring when the amount of film on the reel has dropped to some minimum. The snap switch is connected to reverse the motor which drives the sprockets **164** and **166** so that, as soon as the switch is actuated, the motor will reverse and movement of the film will take place in the opposite direction, the former supply reel now acting as the take-up reel and vice versa. At the same time, the escapement will act to permit the slide **168** to move slightly to the right of its former position. As a consequence, the record made as the film moves in the opposite direction will be displaced slightly laterally.

When the film again builds up on the reel with which the roller 186 cooperates, the switch will be again reversed and the escapement actuated so as to produce another record running in the opposite direction. It will be obvious that this action may be continued to produce a large number of records upon the film, the total record length being thus many times the length of the film.

Instead of reversing the film, it will be clear that the film may be made in the form of a continuous band, lateral displacement occurring at the proper time so as to produce a spiral record.

The film, such as that of Fig. 11, can be readily interpreted by the use of a photoelectric means, responsive to the variations in a pencil of light directed through the records 196. The variations in the response of the photoelectric cell may be noted by an operator or may be caused to actuate an automatic potentiometer or the like giving, thereby, a record on a strip of paper. The dense spots indicated at 198 will, of course, produce corresponding responses in the photoelectric scanning device and hence times which are correlatable with depths may be ascertained. In a graphical record, for example, the time marks will consist of periodic sharp jumps in the record curve.

Inasmuch as there is generally relatively little lateral space available in a well surveying instrument, the mechanism illustrated in Fig. 12 may be used instead of that shown in Figs. 9 and 10. The mechanism of Fig. 12 will produce the same type of record as that illustrated in Fig. 11. In Fig. 12 a guiding member 181 is provided with a transverse slit 183 on the side between the lamps and the film 185. In order to provide an aperture, this slit 183 is intersected by a slit 191 formed in a mask 187 carried at the lower end of a lever 189 which may extend longitudinally of the instrument, the film moving past the slits in an axial direction. The lever 189 is urged toward the right by a spring 193 to bring a pin 195 carried thereby into engagement with one of the steps 197 formed on a slide 199, which is urged in a downward direction by a spring 201 and is held in various positions by escapement mechanism (not shown) cooperating with ratchet teeth 203 formed on the slide. The escapement mechanism may be of any suitable form equivalent to that indicated at 176 and connected with a reversing switch as in the case of the mechanism of Fig. 9. In the operation of the mechanism of Fig. 12, the aperture produced by the cross slits is effectively moved step by step at the time of each reversal of the continuously slowly moving film to produce the type of record indicated in Fig. 11.

The multiplication of the record length may also be accomplished in other fashions as, for example, that illustrated in Figs. 13 and 14. 200 represents a slide such as 168 provided with an opening 202. This slide is connected with a rod 204 provided with teeth meshing with a worm 206 driven through reduction gearing 208 by a motor 210. Projections 214 and 216 on 204 are arranged to engage the lever 218 of a switch 220 connected to reverse the motor 210. A link 224 connected to the switch lever 218 actuates a ratchet 228 through a pawl arrangement indicated at 226, the ratchet 228 driving a shaft 230 connected to a sprocket wheel arranged to advance a film 234.

In the operation of this modification, the film remains stationary while the opening 202 is caused to traverse the film to produce a record such as 236 which resembles the record 196 previously referred to, there being provided in this case also timing spots by intermittent flashing of a timing lamp. As the opening 202 approaches an edge of the film, the switch lever 218 will be engaged and will eventually snap sharply to its alternative position. The motor 210 will then be reversed and at the same time the film will be given a slight sharp advance so that the next traversal will occur in a displaced position. The record will consequently be of the type illustrated in Fig. 14. It will be observed that here again the record may be many times the length of film actually used. The record 236 would, of course, be scanned by a suitable photoelectric arrangement just as the one previously described.

The apparatus disclosed herein is particularly well adapted for operation in connection with a well surveying instrument of the multiple shot type. This is by reason of the fact that there is no necessity for running a cable to the surface. The exploratory unit may be coupled directly below a well surveying instrument of the type, for example, of that described in Williston and Nichols Patent No. 1,960,038, dated May 22, 1934.

In the operation of the instrument it will be obvious that accurate correlations of the readings of the pointer 52 with depth may be secured by noting at the surface by means of a watch synchronized with the clockwork mechanism 102 the times at which various depths are reached. Records correlating depth and time may also be made automatically.

In case it is desired to lower the exploratory apparatus on a drill stem, mechanism may be provided for interrupting the operation of the camera at predetermined times to avoid excessive waste of film during those periods when fourble lengths are being added to the drill stem. Mechanism for accomplishing this result may take the form of a time controlled switch which for periodic intervals may interrupt the illumination by the lamps 86 and 90 and also the feed of the film. Preferably the feed of the film takes place for a short period after the lights are extinguished in order that interruptions in the graph 126 will indicate when the lowering of the instrument was stopped. These form a further correlation of the record with depth.

It will be clear that numerous other variations may be made in the specific embodiment of the invention without departing from its scope.

What we claim and desire to protect by Letters Patent is:

1. Means for determining the location and character of formations penetrated by a bore hole comprising an exploring unit, said exploring unit including a crystal controlled generator of high frequency oscillations, means for establishing thereby an electromagnetic field penetrating formations in the vicinity of the bore hole, said last named means forming a part of a tuned portion of the generator circuit, and means responsive to variations in operation of the generator circuit due to changes of impedance of the field establishing means resulting from different materials in the vicinity thereof; and means for supporting said unit for movement within and lengthwise of the bore hole.

2. Means for determining the location and character of formations penetrated by a bore hole comprising an exploring unit, said exploring unit including a crystal controlled generator of high frequency oscillations, means for establishing thereby an electromagnetic field penetrating formations in the vicinity of the bore hole, said last named means forming a part of a tuned

portion of the generator circuit, and means responsive to variations in operation of the generator circuit due to changes of impedance of the field establishing means resulting from different materials in the vicinity thereof; means for supporting said unit for movement within and lengthwise of the bore hole; and means for producing records of the responses of said responsive means.

3. Means for determining the location and character of formations penetrated by a bore hole comprising an exploring unit, said exploring unit including a crystal controlled generator of high frequency oscillations, means for establishing thereby an electromagnetic field penetrating formations in the vicinity of the bore hole, said last named means forming a part of a tuned portion of the generator circuit, means responsive to variations in operation of the generator circuit due to changes of impedance of the field establishing means resulting from different materials in the vicinity thereof, and means for producing records of the responses of said responsive means; and means for supporting said unit for movement within and lengthwise of the bore hole.

4. Means for determining the location and character of formations penetrated by a bore hole comprising an exploring unit, said exploring unit including a crystal controlled generator of high frequency oscillations, means for establishing thereby an electromagnetic field penetrating formations in the vicinity of the bore hole, said last named means forming a part of a tuned portion of the generator circuit, and means for automatically maintaining substantially constant an operating condition of the generator circuit despite changes of impedance of the field establishing means resulting from different materials in the vicinity thereof, which changes would normally modify said operating condition; and means for supporting said unit for movement within and lengthwise of the bore hole.

5. Means for determining the location and character of formations penetrated by a bore hole comprising an exploring unit, said exploring unit including a generator of high frequency oscillations, means for establishing thereby an electromagnetic field penetrating formations in the vicinity of the bore hole, said last named means forming a part of a tuned portion of the generator circuit, and means for automatically maintaining substantially constant an operating condition of the generator circuit despite changes of impedance of the field establishing means resulting from different materials in the vicinity thereof, which changes would normally modify said operating condition; and means for supporting said unit for movement within and lengthwise of the bore hole.

6. Means for determining the location and character of formations penetrated by a bore hole comprising an exploring unit, said exploring unit including a generator of high frequency oscillations, means for establishing thereby an electromagnetic field penetrating formations in the vicinity of the bore hole, said last named means forming a part of a tuned portion of the generator circuit, and means for automatically maintaining substantially constant an operating condition of the generator circuit despite changes of impedance of the field establishing means resulting from different materials in the vicinity thereof, which changes would normally modify said operating condition; means for supporting said unit for movement within and lengthwise of the bore hole; and means for producing records of the operation of said means for maintaining said operating condition substantially constant.

7. Means for determining the location and character of formations penetrated by a bore hole comprising an exploring unit, said exploring unit including a generator of high freqeuncy oscillations, means for establishing thereby an electromagnetic field penetrating formations in the vicinity of the bore hole, said last named means forming a part of a tuned portion of the generator circuit, means for automatically maintaining susbstantially constant an operating condition of the generator circuit despite changes of impedance of the field establishing means resulting from different materials in the vicinity thereof, which changes would normally modify said operating condition, and means for producing records of the operation of said means for maintaining said operating condition substantially constant; and means for supporting said unit for movement within and lengthwise of the bore hole.

8. Means for determining the location and character of formations penetrated by a bore hole comprising an exploring unit, said exploring unit including a generator of high frequency oscillations, means for establishing thereby an electromagnetic field penetrating formations in the vicinity of the bore hole, said last named means forming a part of a tuned portion of the generator circuit, and means for automatically maintaining substantially constant an operating condition of the generator circuit despite changes of impedance of the field establishing means resulting from different materials in the vicinity thereof, which changes would normally modify said operating conditions, said last named means comprising a variable impedance in said tuned portion of the generator circuit and a motor for reversibly changing said variable impedance; and means for supporting said unit for movement within and lengthwise of the bore hole.

9. Means for determining the location and character of formations penetrated by a bore hole comprising an exploring unit, said exploring unit including a generator of high frequency oscillations, means for establishing thereby an electro-magnetic field penetrating formations in the vicinity of the bore hole, a lamp the luminosity of which is responsive to varying effects upon said field of materials in the vicinity of the field establishing means, and means for producing records of the variations in luminosity of said lamp.

10. Means for determining the location and character of formations penetrated by a bore hole comprising an exploring unit, said exploring unit including a generator of high frequency oscillations, means for establishing thereby an electro-magnetic field penetrating formations in the vicinity of the bore hole, a lamp the luminosity of which is responsive to varying effects upon said field of materials in the vicinity of the field establishing means, and means for producing on a sensitized strip records of the variations in luminosity of said lamp, said records being of linear form and substantially longer than said strip.

11. The method of determining the location and character of formations penetrated by a bore hole comprising generating high frequency oscillations within the bore hole by means of a

generator, establishing thereby a substantially localized electromagnetic field penetrating strata in the vicinity of the bore hole, moving said localized field lengthwise of the bore hole, maintaining substantially constant an operating condition of the generator circuit despite tendencies for variations thereof resulting from different materials in said field, and recording the operations necessary to maintain said operating condition substantially constant.

12. The method of determining the location and character of formations penetrated by a bore hole comprising generating high frequency oscillations within the bore hole by means of a crystal controlled generator, establishing thereby a substantially localized electromagnetic field penetaining substantially constant an operating conmoving said localized field lengthwise of the bore hole, maintaining substantially constant an operating condition of the generator circuit despite tendencies for variation thereof resulting from different materials in said field, and recording the operations necessary to maintain said operating condition substantially constant.

13. Means for determining the location and character of formations penetrated by a bore hole comprising an exploring unit, said exploring unit including a vacuum tube generator of high frequency oscillations and means for establishing thereby an electromagnetic field penetrating formations in the vicinity of the bore hole, the grid current of said generator being affected by materials in the vicinity of the field establishing means; and means for producing indications of said grid current.

14. Means for determining the location and character of formations penetrated by a bore hole comprising an exploring unit, said exploring unit including a crystal controlled generator of high frequency oscillations, means for establishing thereby an electromagnetic field penetrating formations in the vicinity of the bore hole, a lamp the luminosity of which is responsive to varying effects upon said field of materials in the vicinity of the field establishing means, and means for producing records of the variations in luminosity of said lamp.

CHARLES B. BAZZONI.
JOSEPH RAZEK.

CERTIFICATE OF CORRECTION.

Patent No. 2,167,630. August 1, 1939.

CHARLES B. BAZZONI, ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 5, second column, line 34, for the reference numeral "174" read 184; page 8, first column, lines 16 and 17, strike out "pene-taining substantially constant an operating con-" and insert instead the words and comma penetrating strata in the vicinity of the bore hole; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 12th day of September, A. D. 1939.

Henry Van Arsdale,
(Seal) Acting Commissioner of Patents.

CERTIFICATE OF CORRECTION.

Patent No. 2,167,630. August 1, 1939.

CHARLES B. BAZZONI, ET AL.

It is hereby certified that in Certificate of Correction issued September 12, 1939 in the above numbered patent, in lines 8 and 9, the insertion "penetrating strata in the vicinity of the bore hole" should read penetrating strata in the vicinity of the bore hole,; so that the said Certificate may conform to the record of the case in the Patent Office.

Signed and sealed this 3rd day of October, A. D. 1939.

Henry Van Arsdale,
(Seal) Acting Commissioner of Patents.

Jan. 14, 1941. G. H. ENNIS **2,228,623**

METHOD AND MEANS FOR LOCATING PERFORATING MEANS AT PRODUCING ZONES

Filed June 25, 1940 4 Sheets-Sheet 1

Fig. 1a

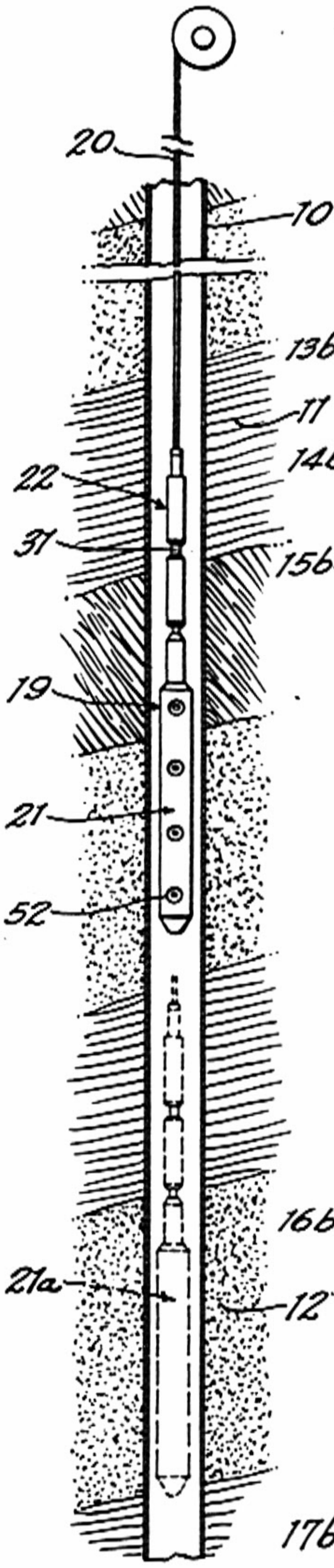


Fig. 1b

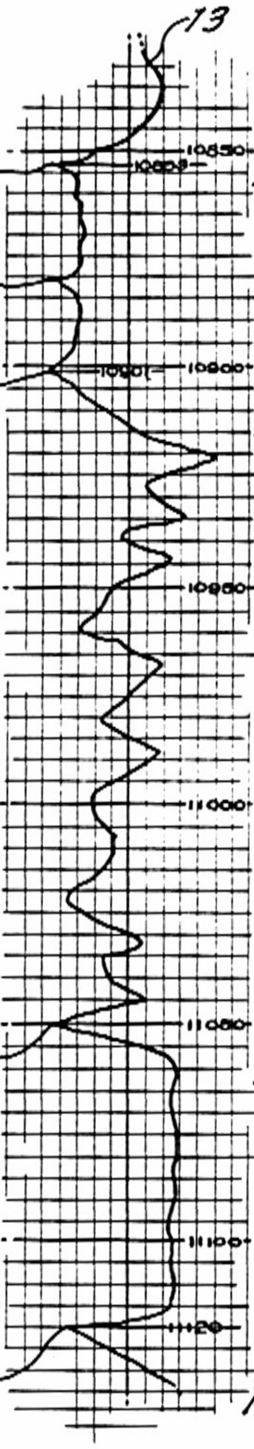


Fig. 1c

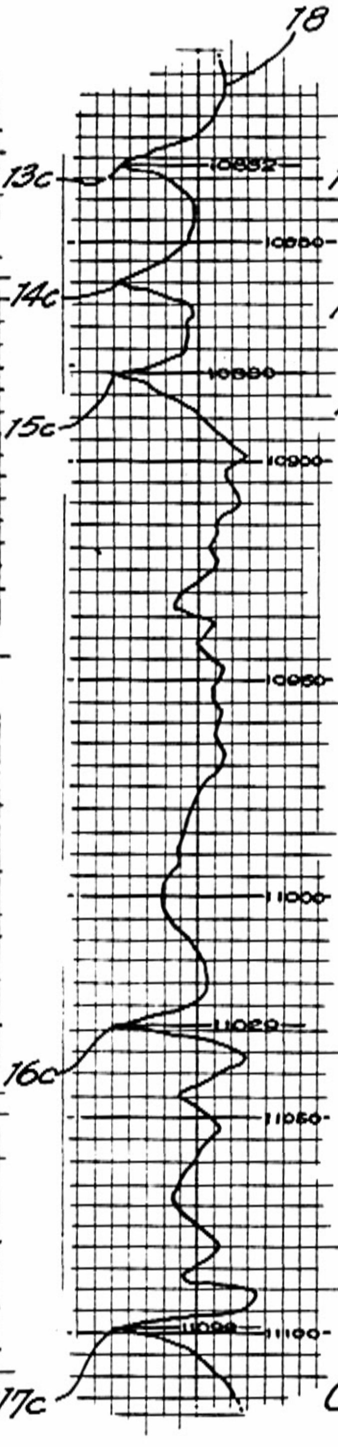
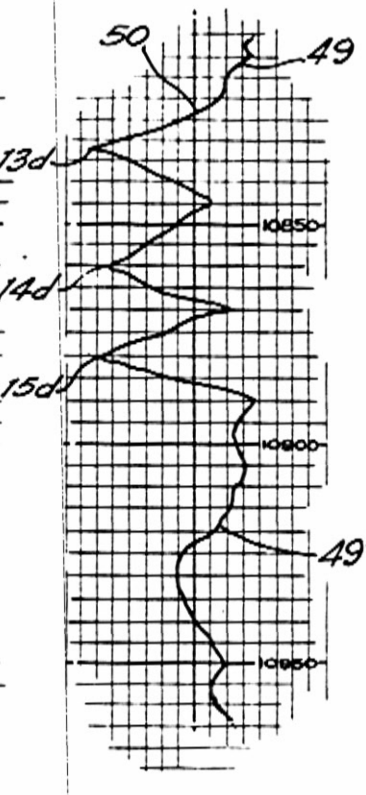


Fig. 1d



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ATTORNEY.

155

Jan. 14, 1941. **G. H. ENNIS** **2,228,623**

METHOD AND MEANS FOR LOCATING PERFORATING MEANS AT PRODUCING ZONES

Filed June 25, 1940 4 Sheets-Sheet 2

Fig. 2

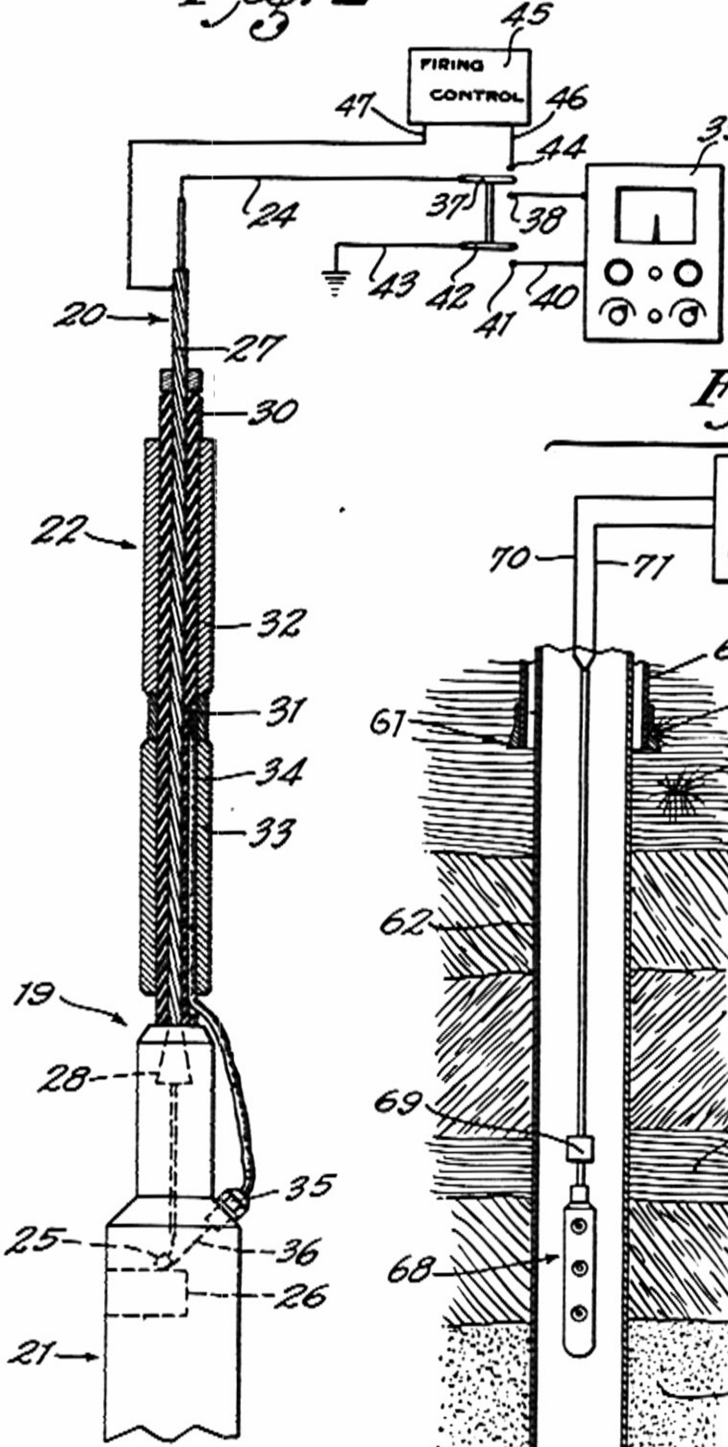
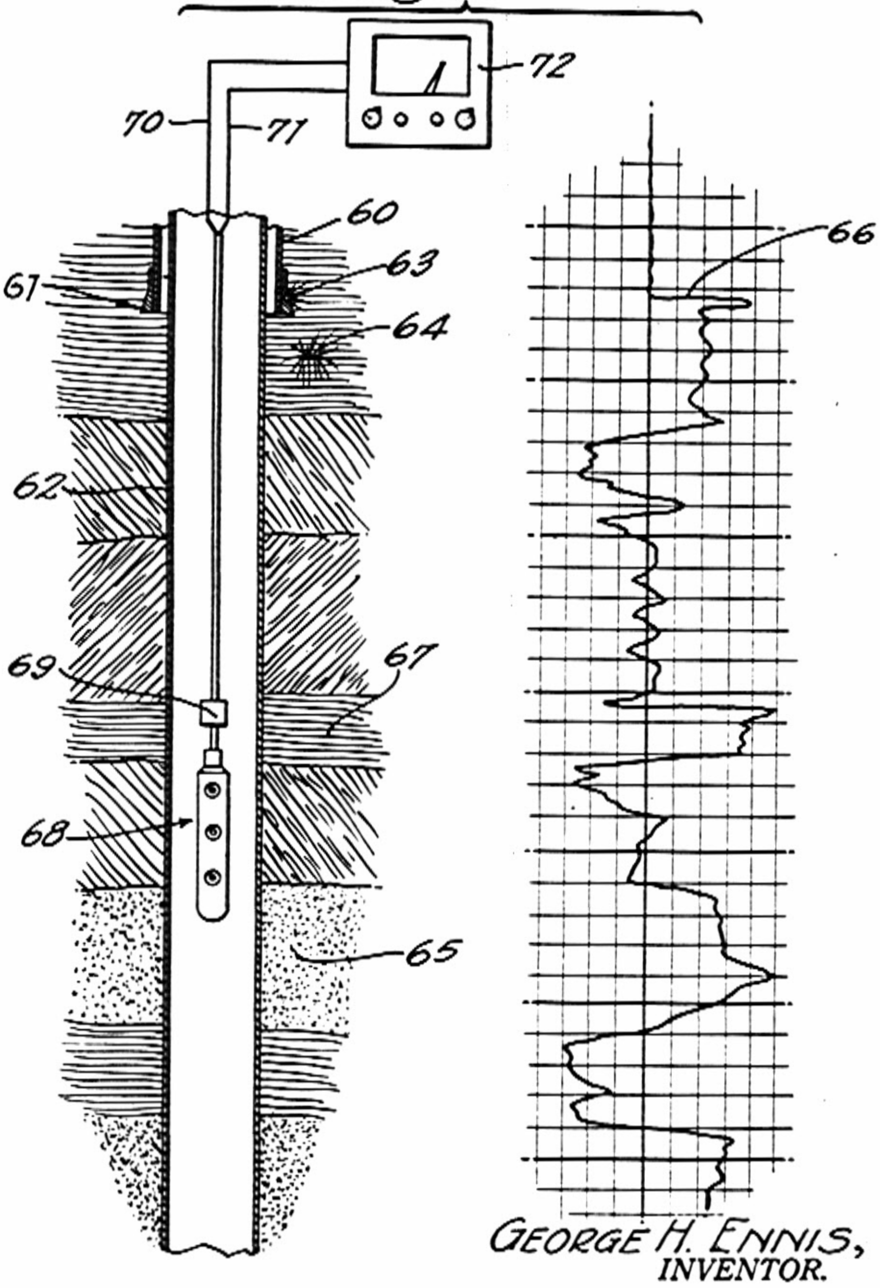


Fig. 3



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Jan. 14, 1941. G. H. ENNIS **2,228,623**

METHOD AND MEANS FOR LOCATING PERFORATING MEANS AT PRODUCING ZONES

Filed June 25, 1940 4 Sheets-Sheet 3

Fig. 4

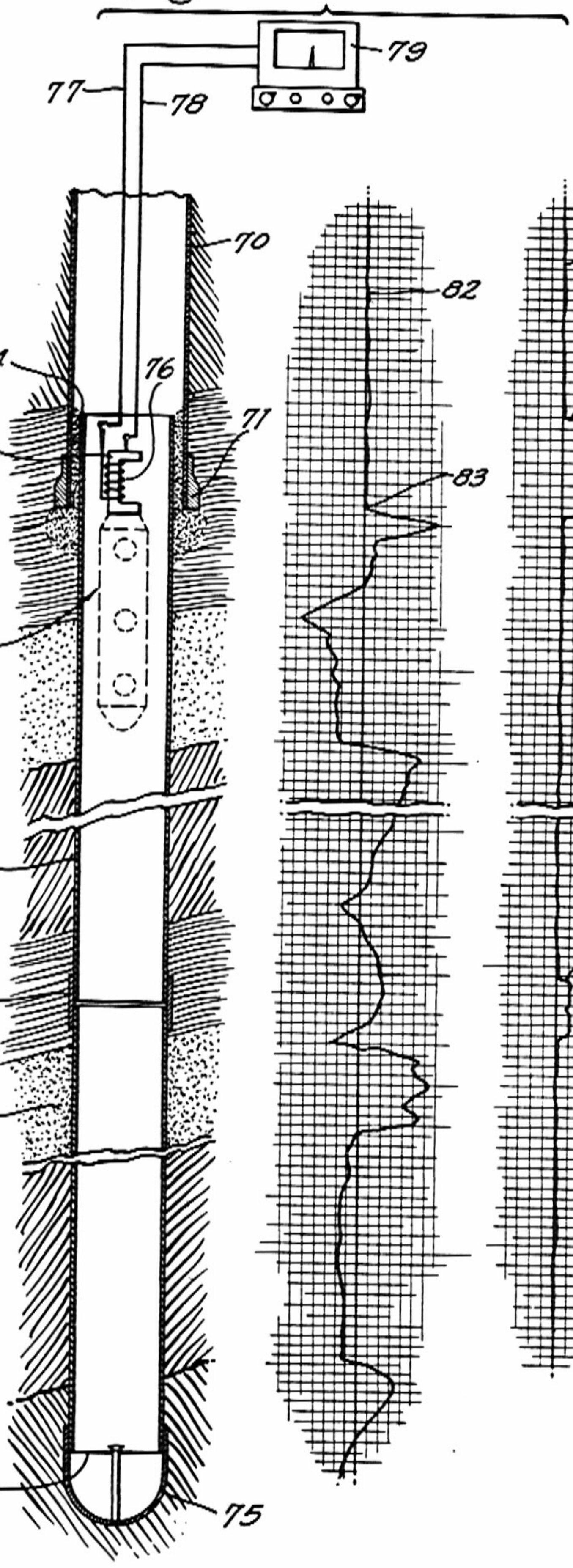
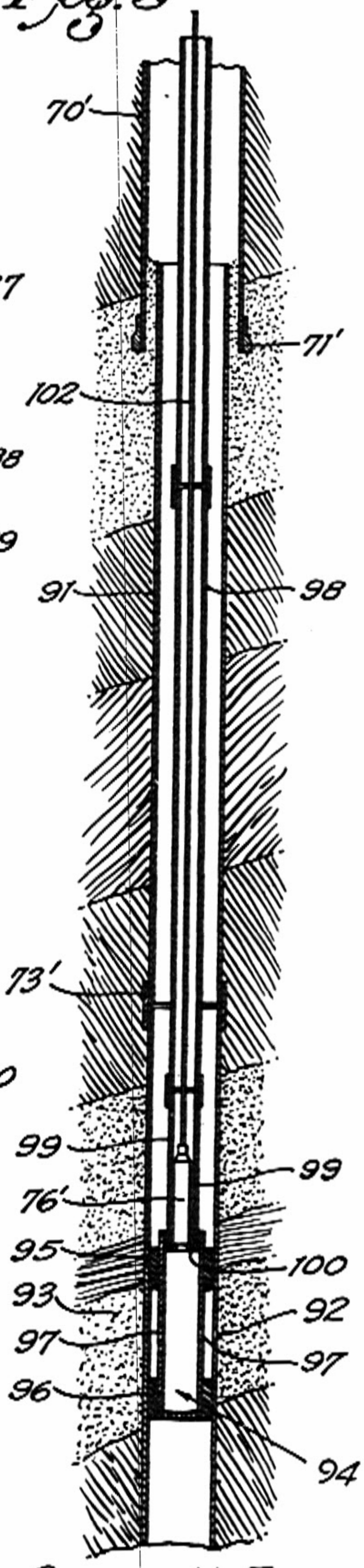


Fig. 5



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Jan. 14, 1941. G. H. ENNIS **2,228,623**

METHOD AND MEANS FOR LOCATING PERFORATING MEANS AT PRODUCING ZONES

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Fig. 6

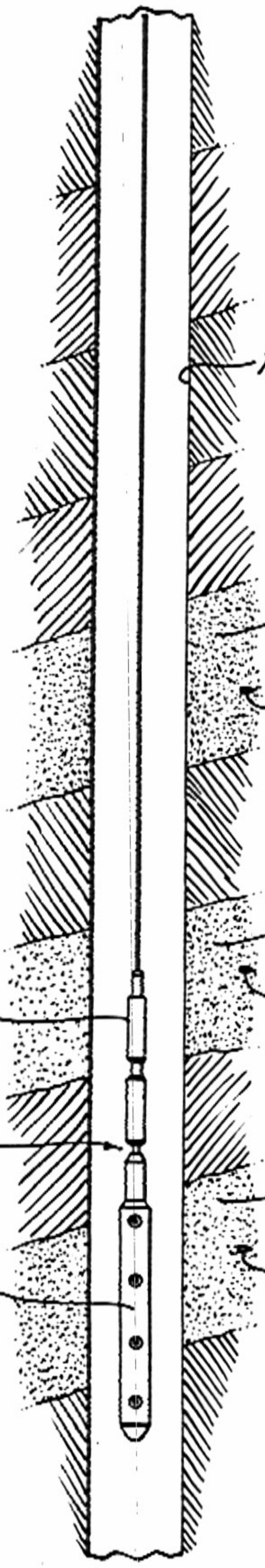
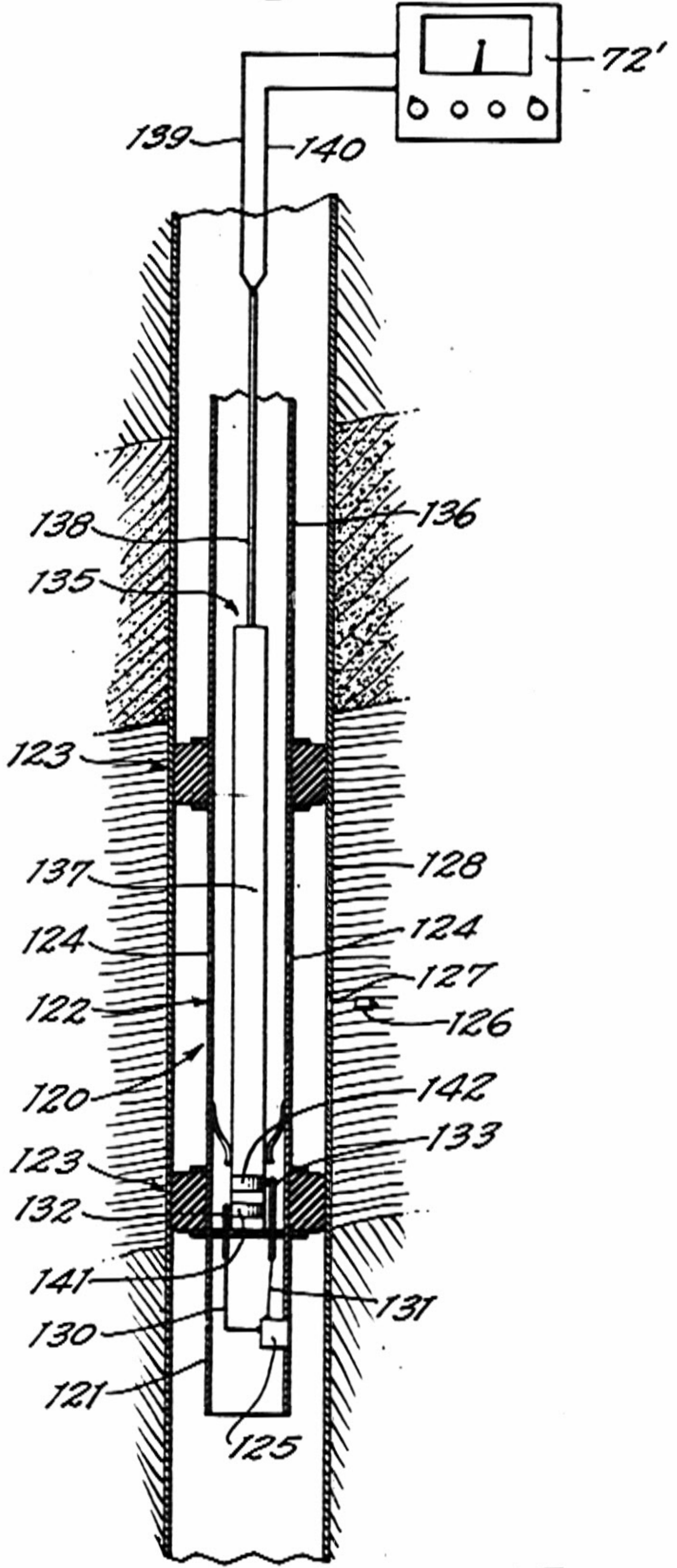


Fig. 7



GEORGE H. ENNIS,
INVENTOR.

BY

ATTORNEY.

Patented Jan. 14, 1941 2,228,623

UNITED STATES PATENT OFFICE

2,228,623

METHOD AND MEANS FOR LOCATING PERFORATING MEANS AT PRODUCING ZONES

George H. Ennis, Long Beach, Calif., assignor of one-half to Robert V. Funk, Long Beach, Calif.

Application June 25, 1940, Serial No. 342,320

17 Claims. (Cl. 255—1)

My invention relates broadly to method and means for establishing positions within deep wells, and relates in particular to a method and apparatus for use in bringing a well into production.

In the present art of producing oil from subterranean formations, it has now become accepted practice to drill the well into or through one or more oil bearing formations, to set the casing in the well and then perforate the casing to permit entry of oil from one or more of the formations. For the purpose of perforating casing after it has been set in a well, several different types of equipment have been developed, including mechanical perforators having spikes or blades which are forced by heavy pressure out through the wall of the casing, and gun perforators by which bullets are shot through the casing wall. In the use of either of these types of perforators, the perforating device is lowered into the casing on the lower end of a suspension member, either tubing or cable. As the device is lowered into the well the length of the suspension member lowered into the well is measured, for the purpose of determining the distance of the device from the top of the well at any time. This determination of the position of the perforator is only approximate, in view of different factors involved. The suspension member, although it is made from steel, is elastic, and stretches in accordance with the load applied thereto. Accordingly, when any device, such as a perforating tool, is lowered into a well by means of a cable, the methods at present used do not dependably indicate the distance of the device below the surface of the ground, even though corrections have been made in footage tabulations in accordance with the involved theoretical factors of deviation.

How the foregoing presents a problem in the perforating of oil well casings will be seen from the following. The log of a well may indicate that an oil sand is positioned between levels which are indicated as being at different distances from the top of the well. These distances shown by the log of the well, as a general rule are found to be inaccurate. The operator of the perforating device, using the log as a guide, must position the perforating device in the well by measuring the length of the suspending cable paid out during the lowering of the device, and making corrections to compensate for factors of variation including cable stretch and flotation. The errors of dimensions indicated on the log of the well and the errors involved in the positioning of the perforating device by means of a cable may be cumulative, with the result that when the perforator is actuated it will fail to perforate the casing between the levels constituting the limits of the oil sand, or the perforations may entirely miss the oil sand and, further, may connect the interior of the casing with a water bearing stratum. It is an object of the present invention to eliminate uncertainty in the locating of a device of this type in a well by providing a method and apparatus whereby the device may be very accurately positioned in a well with relation to a specified zone or position.

It is an object of the invention to provide a method and apparatus whereby a marker is established and/or identified with relation to a selected zone which is intersected by the well, and whereby this marker is employed to locate a tool or device in a desired position relative to the zone, by direct reference to the marker, thereby avoiding the errors resulting from the locating of the tool or device with reference to the top of the well.

It is an object of the invention to provide a method and apparatus whereby a device of the general type above mentioned may be positioned accurately with relation to a selected position or zone below the surface of the ground, and wherein a marker is established in proximity to the zone or location, the establishing of this marker involving determination of the distance from the marker to the zone or position, and then locating the device certainly and accurately in the selected zone or position through employment of the simple expedient of placing the device in a desired distance relation to the marker.

A further object of the invention is to provide a method and apparatus whereby a casing perforator is lowered into a well and is actuated when it is in a selected position relative to a marker established at a distance below the surface of the ground, thereby making it possible to assure practical accuracy in locating the perforations in the casing opposite a selected oil sand or in a selected production zone.

It is an object of the invention to provide a process and apparatus whereby a perforator may be accurately located relative to a selected production zone by establishing a marker in relation and proximity to the production zone, then lowering a perforator into the casing, and also lowering into the casing a marker locating means capable of producing an indication sensible to an operator stationed at the top of the well when it is brought to a position coinciding with the marker, and thereafter moving the perforator into such position relative to the located marker as to lie in the production zone. It will be recognized that this marker may be above or below, or within the limits of, the production zone, and the accurate positioning of the perforator is simply accomplished by spacing it a required distance from the marker, which distance may vary from zero value to a value of several hundred feet.

It is an object of the invention to provide a method such as set forth in the preceding paragraph wherein the marker locating means is connected to the perforator so as to move therewith, and wherein the combined marker locating and perforating assembly is lowered into the well casing to the point at which the marker is located, and is then moved from this location the distance required to bring the perforator into the selected production zone.

It is an object of the invention to provide a method and apparatus for accurately locating a device in a well by first establishing below the surface of the ground a marker in known relation to a selected stratum, moving the device down the well to a marker position, and then moving the device from this marker position the prescribed or computed distance necessary to bring the device accurately into the final position thereof. The term "marker position" employed in the foregoing is any position adjacent or close to the marker which may be determined by suitable locating means of one of the various types to be hereinafter described.

Further objects and advantages of the invention will be brought out in the following part of the specification.

Referring to the drawings which are for illustrative purposes only.

Fig. 1*a* is a schematic view showing a portion of a casing extending through strata, one of which comprises an oil sand from which production of oil is desired.

Fig. 1*b* is a representation of a log obtained prior to the placing of the casing in the well.

Fig. 1*c* is a representation of another log of the well section shown in Fig. 1*a* after the casing is set.

Fig. 1*d* is an electrical log or stratagraph taken after installation of the casing in the well section shown in Fig. 1*a* in conjunction with the location and operation of a perforator in the well casing.

Fig. 2 is a partly sectioned view showing the details of the testing device which is connected to the upper end of the perforator.

Fig. 3 is a schematic illustration showing a practice of my invention wherein radio active materials are employed as markers.

Fig. 4 is a schematic view showing another method of practicing my invention.

Fig. 5 is a schematic view showing my invention in use for accurate location in a well of a device other than a perforator.

Fig. 6 is a schematic view of a section of the well showing a manner in which markers may be positioned in sands.

Fig. 7 is a sectional view of diagrammatic character showing a cementing device which may be used in the exploration of a cased well.

Fig. 1*a* is illustrative of a condition met in the drilling of wells. The well casing **10** intersects a stratum **11** of shale, below which there lies an oil bearing stratum or oil sand **12**. An electrical graph or log **13**, prepared prior to the setting of the casing **10** shows that the upper and lower limits of the shale **11** are respectively at 10,853 feet and 10,901 feet below the top of the well, and that the upper and lower limits of the oil sand **12** are respectively 11,050 and 11,120, the distance from the bottom of the shale to the top of the oil sand being 149 feet (11,050—10,901=149). The excursions **13***b*, **14***b*, and **15***b* of the curve **13** clearly identify the position of the shale **11** on the log Fig. 1*b*, and on this log the excursions **16***b* and **17***b* clearly indicate the limits of the oil sand **12**. The log Fig. 1*c*, comprising a graph or curve **18**, is placed adjacent the graph **13** so that the excursions **13***c*, **14***c*, and **15***c* indicating the shale **11**, will lie opposite the corresponding portions of the graph **13**. When this is done, it will be found that the excursions **16***c* and **17***c* lie adjacent the excursions **16***b* and **17***b* of graph **13**. Although the graphs **13** and **18** agree in the portions thereof indicating the shale **11** and the oil sand **12**, the graph **18** shows these indications at a different distance from the top of the well, than is shown by graph **13**. For example, the lower limit of the shale **11** is indicated by graph **13** as being at a level of 10,901, but in graph **18** the point **15***c* indicating the lower level of the shale **11** occurs at the measurement 10,880 or 21 feet above the point **15***b* of graph **13**. All of the points of interest on the graph **18** appear to be 21 feet above the positions indicated for them on the graph **13**. For example, the upper limit of the oil sand **12**, appearing at 11,050 on graph **13** is to be found at 11,029 on graph **18**, and the lower limit of the oil sand **12**, appears to be raised from 11,120 to 11,099. It is to be noted, however, that in each of the graphs **13** and **18** the thickness of the shale **11** is indicated as 48 feet, the thickness of the oil sand **12** is indicated as 70 feet, and that the distance from the point **15***c* to the point **17***c* of graph **18** is the same as the distance from point **15***b* to the point **17***b* of graph **13**, namely, 219 feet, establishing that the distance from the lower limit of the shale **11** to the lower limit of the oil sand **12** is of this value. Furthermore, the logs represented by the curves **13** and **18**, correlated with the driller's log of the well, both clearly show the distance from the lower limit of the shale **11** to the upper limit of the oil sand **12** to be 149 feet, regardless of the fact that the charts **13** and **18** show the shale and the oil sand at different levels from the top of the well.

Due to changes in cable lengths and other sources of error, the logs shown in Figs. 1*b* and 1*d* do not establish the distances of the selected shale and oil bearing strata from the surface of the ground, but they definitely establish, either by themselves or in combination with driller's records, the correlative positions of the limits of the shale and oil bearing strata. If an operator were to now lower a perforating device down into the casing **10**, computing the necessary amount of cable **20** which must be fed into the well to bring the perforating device to a position adjacent the oil sand **12**, he would have no assurance that the perforating device is in this intended position, for this operation would be subject to all the factors of error encountered in the lowering of the device into a well by means of a suspension member such as a cable or string of tubing.

My present invention provides a simple method and apparatus whereby all error in the location of the device relative to the oil sand **12** is substantially eliminated. I accomplish this valuable result by establishing a marker in proximity to the oil bearing formation **12**, which marker may be readily located at any time and may be used as a guide for the positioning of the perforator. In the present instance the graphs **13** and **18**, or either of them singly, establish the shale stratum **11** as a marker which may be readily located at any time either before or after the setting of the casing **10**. Accordingly, I lower a perforating device such as a perforating gun **21** down into the casing **10**, in association with a marker locating means **22**, to locate the shale **11**, or in this instance the lower limit thereof, after which the perforating gun **21** may be moved down into the zone defined by the upper and lower limits of the oil sand **12** and there actuated. In Fig. 2 I have schematically shown a combined marker locating and perforating means **19** consisting of the gun perforator **21** and the locating means **22** of Fig. 1*a*. The gun **21** may be of any desired type such as now employed in the perforating of casing. Such a gun, as now well known to the art, has one or more gun barrels with associated powder chambers to carry the projectiles and firing charges, with means for setting off the powder charges at a desired time. In Fig. 2 I show the cable **20** as having an insulated conductor **24** extended therethrough. The lower end of this conductor **24** is carried into the top of the gun perforator and connected to a terminal **25** of the firing switch **26** of the gun, and the metal sheath **27** of the cable is connected to the upper part of the body of the gun as indicated by dotted lines **28**.

The locating means **22** comprises a sleeve of insulating material, having an opening therethrough of such size that it may be slipped over the cable **20**, a metal elctrode **31** disposed centrally upon the sleeve **30**, and sleeves **32** and **33** which surround the sleeve **30** above and below the electrode **31**. A conductor **34** is connected to the electrode **31** and is carried down between the sleeve **33** and the lower portion of the sleeve **30** to the lower end of the locating means **22**. The lower portion of the conductor **34** is carried through a suitable seal or packing device **35** at the upper end of the body of the gun **21** and as indicated by dotted lines **36** is connected to the terminal **25**, so as to be then in connection with the conductor **24**.

As diagrammatically shown in the upper part of Fig. 2, the conductor **24** may be connected to a movable switch member **37** adapted to be brought into engagement with a contact **38** which is connected with an electrical recorder **39** having a ground circuit consisting of a conductor **40** which leads to a contact **41**, a movable switch member **42** and a ground connection **43** which may be connected to the earth or to the casing **10**. A contact **44** is placed in spaced relation to the contact **38** and is connected to the firing control **45** by means of a conductor **46**, and from the firing control **45** a conductor **47** is extended to the sheath **27** of the cable **20** to complete the firing control circuit for the gun **21**.

The manner of operation of the combined locating and perforating means is as follows. The assembly comprising the gun **21** and the locating means **22** is lowered down through the well and through the casing **10**, and as the level of the stratum **11** is approached, the movable switch members **37** and **42** are moved into engagement with the contacts **38** and **41** thereby closing the recording circuit which includes the stratagraph recording device **39** which will scribe a graph or curve **49** of the general character shown in Fig. 1*d*. As the electrode **31** moves downward within the casing **10**, the electro-potential changes in the recording circuit will produce a record or graph which may be correlated with the graphs **13** and **18**. It is found that with present equipment, the existence of the casing **10** between the electrode **31** and the formation may under some conditions have a damping effect on the electrical changes in the recording circuit and that the graph obtained thereby will not be as complete in detail as a graph made by the open hole method, for example, a graph such as shown at **18**.

However, the graph obtained as the result of the operation of equipment of the character shown in Fig. 2, within the casing of a well, will clearly distinguish certain types of formation, such for example, as shale. Therefore, the shale **11** has been established as the marker in the present instance. As the electrode **31** approaches the upper level of the shale **11** the curve will move leftward as indicated at **50**, and a point will be formed at **13***d* corresponding to the point **13***b* and **13***c* of the graphs **13** and **18**. Likewise, excursions **13***d*, **14***d*, and **15***d* will be formed, thereby definitely locating the marker **11**. When the electrode **31** reaches a position at the lower limit of the shale **11**, as shown in Fig. 1*a*, the scribing needle of the recorder **39** will be at the point or excursion **15***d*, thereby bringing to the operator at the top of the well knowledge that the electrode **31** is in a starting position, or in an initial position from which the assembly of elements **21** and **22** may be moved to bring the gun **21** into cooperation with the oil sand **12**. Ordinarily the electrode **31** is lowered some distance below the shale **11** so that the portion **49′** of the graph **49**, below the point **15***d*, will be scribed. The correlation of the points **13***d*, **14***d*, and **15***d* to similar excursions found in the graphs **13** and **18** having been recognized, the assembly of members **21** and **22** will be at this time moved upward to retrace the lower portion **49′** of the graph **49** in reverse direction, the upward movement of the cable **20** being stopped when the point **15***d* is reached, thereby assuring that the marker, in this instance the lower level of the shale **11**, has been located and that the perforating gun **21** is in "marker position." By marker position is meant that the gun **21** is in a known relation to the marker and that it is ready for such movement as will bring it into the proper position for firing. Accordingly, if the lowermost barrel **52** of the gun **21** is 10 feet below the electrode **31**, the downward movement of the gun **21** to bring this barrel **52** to a position adjacent the lower limit of the oil sand **12** will be 10 feet less than the distance from the marker to the lower limit of the oil sand, or, namely, 209 feet. The change in the length of the cable **20** during the movement thereof through a distance of 209 feet will be so small that the barrel **52** may be readily located with practical accuracy at the point desired, and the gun **21**, as indicated by dotted lines **21***a* in Fig. 1*a*, may, with reference to the marker comprising the lower limit of the shale, be very accurately positioned at any point relative to the marker, within the limits of 500 or 1000 feet above or below the same, without having actual knowledge of the distance of the gun **21** from the top of the well. Under some conditions the active stratum may serve as its own marker in the positioning of a fluid entry means, but it is often found that an electrically prepared graph taken after the setting of the casing, does not dependably indicate oil sands; whereas, other strata are clearly indicated.

In Fig. 1a I have shown an embodiment of my invention wherein a selected stratum is established as a marker. In Fig. 3 I show a form of the invention wherein establishment of a marker includes the placing of the marker in the formation or in a structural member of the well, such as the casing. In Fig. 3 I have shown a casing 60 having a shoe 61, with a casing member or liner 62 projecting downward from the casing 60 to be used as a marker, a small body 63 of radio active material may be connected to the lower part of the casing 60, for example, the body 63 may be held in a recess in the shoe 61. Likewise, a body of radio active material 64 may be placed in the formation as desired. For example, the body 64 may be a projectile which has been shot into the formation by use of a gun, preferably before the casing is set. Either of the markers 63 or 64, or both of them, may be correlated with a selected stratum, such as the oil sand 65, by information taken from the driller's log or from an electro-log 66 made prior to the setting of the casing 62, so as to show the strata below the shoe 61 and to relatively accurately show the distances between the markers 63 and 64 and the upper and lower limits of the stratum 65. In this instance, a stratum 67 of radio active material may be employed as a marker and this marker may be correlated with the markers 63 and 64, making it possible to very accurately locate a gun or other device 68 in the well, by employing in conjunction with the gun a locating means comprising a device 69 which is sensitive to radio active emissions, the device 69 being connected through conductors 70 and 71 with a sensitive recording device 72 in accordance with the general teachings of the U. S. Patent No. 2,133,776, granted October 18, 1938, to J. C. Bender.

A body of metal may be placed in the earth and established as a marker. Such body of meal may be a block of iron, or may be a portion of a casing member. In Fig. 4 I show an outer casing 70 having an iron shoe 71 which may be established as a marker by correlating it with the strata, and I show a liner or casing 72 having collars such as indicated at 73, and a bottom 74 formed by a plug 75, which by proper correlation with the strata may be established as markers which may be readily located.

In Fig. 4 I have diagrammatically shown an induction device for locating a marker, this induction device including a coil 76 connected in circuit through conductors 77 and 78 with a recording device 79. The coil 76 is wound upon a C-shaped field member or core 80. As the coil 76 is moved within the casings 70 and 72, in association with a device such as a perforating gun 81, the concentration of the magnetic field will be changed by the presence of any body of magnetic material encountered, with a resulting change in the inductance of the coil 76 and a change in the flow of current through the connected electro-responsive parts of the recording device 79. In Fig. 4 I have shown adjacent the casing members 70 and 72 an open-hole graph taken after the setting of the casing 70 and prior to the placing of the liner or casing 72, the portion 83 of the graph 82 definitely establishing the position of the shoe 71 as a marker in correlation with the strata. After setting of the casing member 72, the upper end 84 thereof, the shoe 71, and the collars 73 of the casing member 72 may be employed as markers, for they may be all esablished as such with relation to the formation. For example, in the making up of the casing member 72, the pipe sections forming the same may be measured so that the distances between all of the collars 73 will be known. Accordingly, thereafter the position of each collar 73 relative to the oil sand 86 may be be readily computed, with reference to the shoe 71, the distance of which from the oil sand 86 is definitely established.

In Fig. 4 I have shown a graph 87 representative of the graph scribed on a strip of paper by the needle of the recording device 79 as the coil 76 is lowered in the casing members 70 and 72. When the coil 76 reaches the upper end of the cashing member 72 there will be a rightward excursion of the graph at 88 and a further excursion at 89 as the coil 76 passes the shoe 71. Thereafter an excursion of the graph such as shown at 90 will locate each collar 73. By use of the general principles disclosed relative to Figs. 1 and 3, the arrangement shown in Fig. 4 may be employed to accurately position a device, such as the device 81 opposite a selected stratum, such as the oil sand 86, and an especial advantage of the apparatus and method disclosed is that in the perforating of the casing member 72 the collars 73 may be employed as markers in locating the gun and also as a means for locating the collars 73 so that they may be avoided in perforating the casing.

In Fig. 5 I show a casing 91, set in a well and which has been perforated at 92 for the purpose of exploration. The perforation 92 has been formed, as by the shooting of a projectile therethrough, at a prescribed distance from an established marker such as a collar 73′, the upper or lower end of the casing 91 or the shoe 71′ at the lower end of an outer casing 70′, so as to establish communication with the sand stratum 93 to determine if oil may be obtained therefrom. It having been found that the production from the stratum 93 comprises water, the form of my invention shown in Fig. 5 makes it possible to readily close the perforation 92 by the application of cement. A cementing head 94, having expansible sealing or packing means 95 and 96 above and below outlet ports 97 in the cylindrical wall thereof, is connected to the lower end of a string of tubing 98 by means of a short section 99, this section having a stop or shelf 100 near the lower end thereof and being of non-magnetic metal, such as brass. When the cementing head has been lowered substantially to the position of the selected marker, for example, the collar 73′, a locating means 76′ of inductive character, as disclosed in Fig. 4, is lowered into the tubing 98 by means of a cable 102 having a conductor therein, and this inductive type of locating means 76′ is brought to rest in a known position in engagement with the stop 100. The assembly of parts comprising the head 94 and the marker locating element 76′ is then moved within the casing 91 until the marker 73′ is located, thereby bringing the cementing head 94 into a known position, which may be referred to as the "marker position." With the location of the cementing head 94 relative to the perforation 92 thus known, the head 94 is then lowered the desired distance from its marker position to bring it into a position of cooperation with the aperture 92, as shown in Fig. 5, after which the locating device may be withdrawn from the tubing 98 and a suitable amount of cement mixture may be pumped down through the head and out through the perforation 92 to close the same, leaving the well in condition for further exploration proceedings consisting in the shooting of projectiles through the wall of the casing 91 into other strata and inspecting the production from such strata, and closing such of the perforations which are found to make connection with non-productive strata.

An important advantage of my present invention is that it provides a means for a thorough exploration of a well to discover and bring into production oil sands which under ordinary circumstances are neglected. In one practice of the invention markers may be established prior to the setting of the casing, by placing selected marker means in selected formations. In Fig. 6 I show a bore hole prior to the setting of a casing, this bore hole intersecting a number of sands 110, 111, and 112. During the drilling process, or when the same is completed prior to the setting of the casing, markers may be placed in these sands so that after the casing is set each of the sands may be readily located and tested in the manner set forth in the description of Fig. 5. As shown in Fig. 6, a combined testing and perforating device 19 of the character shown in Figs. 1 and 2 is lowered into the hole 109 and an electrometric log or graph such as shown at 18 in Fig. 1c is prepared. On such log many sands are indicated, but it is not always possible to determine from the log itself whether these sands are oil sands or water sands. However, the gun 21 is operated at proper times to fire into each of the sand formations a projectile 113 of or containing an active material, such as a radio active material which will make possible the accurate location of each projectile or marker at a later time, for example, after the casing is set.

After the setting of the casing a perforating gun 68, with an associated marker locating means 69, such as shown in Fig. 3, may be lowered into the casing and any one of the markers 113 may be located and one or more projectiles may be fired through the casing to perforate the casing adjacent the oil sand containing the selected marker. Then the necessary steps may be taken to determine the type of fluid, if any, contained in the selected sand, and if the selected sand should contain water instead of oil, the perforations made thereat for the purpose of test may be closed by the application of cement, and at the position indicated by another of the markers 113 other test perforations may be made in the casing. By a repetition of the process discussed in the foregoing the well may be carefully explored. It will be recognized that the placing of the radio active markers 113 may be performed after the setting of the casing. For example, the combined perforating and testing or marker locating device 19, shown in Fig. 1*a*, may be employed to first shoot a radio active bullet, or several of them, through the wall of the casing into the formation. The formation may be tested through the openings thus formed and if an oil production is obtained other perforations may be made in the casing at the production stratum thus discovered, or if an oil production is not obtained from this stratum, the radio active bullets may be employed as markers whereby the test perforations may be located and then closed, as by the application of cement.

In Fig. 7 I have shown diagrammatically a combined testing, cementing and marker locating device 120, comprising a casing 121 secured to the lower end of a tubular cementing head 122, having packing means 123 at the ends thereof, or respectively above and below cement outlet ports 124 in the side wall thereof. The casing 121 has a cell 125 which is responsive to a selected character of electronic emanation, in accordance with the type of material employed in a projectile 126 by which a perforation 127 has been previously made in a casing 128. For example, the projectile 126 may comprise a radio-active or activatable material. The cell 125 is connected by conductors 130 and 131 with contacts 132 and 133 disposed within the cementing head 122. After this combined cementing and marker locating device 120 is lowered in the casing 128 to approximately the level of the marker 126, circuit forming means 135 may be lowered through the tubing 136 by which the device 120 has been lowered in the casing 128. This circuit forming means 135 comprises a bar or weight 137 carried at the lower end of a cable 138 which has conductors 139 and 140 extending therethrough. At the lower end of the member 137 annular contacts 141 and 142 are carried in such positions that when the member 137 reaches the bottom of the cementing head 122, these contacts 141 and 142 will engage the contacts 132 and 133, thereby connecting the conductors 130 and 131 with the cable conductors 139 and 140, with the result that the responsive element 125 will be placed in circuit with the electrical parts of a recording instrument 72′ located at the top of the well to which the conductors 139 and 140 are connected.

The combined cementing and marker locating device may be then moved within the casing 128 until the recording device 72′ indicates that the responsive element 125 is in the horizontal plane defined by the marker 126. The operator, having knowledge of the distance from the responsive element 125 to the center of the cementing head 122 may then lower the device 120 a sufficient distance to bring the cementing head 122 into centralized relation to the perforation 127; whereupon, the circuit forming means 135 may be withdrawn. The pressure in the tube 136 may be then reduced to make a test through the opening 127, and if the formation is found to be non-productive, cement may be forced down through the tubing 136 and out through the openings 124 of the cementing head 122 of the perforation 127.

If the formation is found to be productive, the device 120 will be withdrawn from the casing 128 and a perforating device of the type herein disclosed may be employed to increase the number of perforations in the casing 128 communicating with the productive formation, using the projectile 126, or other marker, as a guide for this operation.

I claim as my invention:

1. In a method of producing a fluid from the earth, the steps of: forming in the earth a bore hole which intersects a production stratum; preparing a log of the formations intersected by said bore hole, said log showing said production stratum; establishing a marker below the surface of the earth and in a known relation to said production stratum; setting a casing in said bore hole so as to intersect said production stratum; locating said marker; and then perforating said casing in a position correlated with said marker and determined in accordance with said known relation of said production stratum and said

marker, whereby said perforating will connect the interior of said casing with said production stratum.

2. In a method of producing a fluid from the earth, the steps of: forming in the earth a bore hole which intersects a production stratum; preparing a log of the formations intersected by said bore hole, said log showing said production stratum, said log including an electrometric record of the formations intersected by said bore hole; establishing a stratum as a marker below the surface of the earth and in a known relation to said production stratum; setting a casing in said bore hole so as to intersect said production stratum; locating said marker by electrometric means; and then perforating said casing in a position correlated with said marker and determined in accordance with said known relation of said production stratum and said marker, whereby said perforating will connect the interior of said casing with said production stratum.

3. In a method of producing a fluid from the earth, the steps of: forming in the earth a bore hole which intersects a production stratum; establishing a marker below the surface of the earth and in a known relation to said production stratum; setting a casing in said bore hole so as to intersect said production stratum; locating said marker; and then perforating said casing in a position correlated with said marker and determined in accordance with said known relation of said production stratum and said marker, whereby said perforating will connect the interior of said casing with said production stratum.

4. A method of producing a fluid from the earth wherein a well intersects a production stratum, a marker is established in a known relation to said production stratum independently of the location of said production stratum relative to the top of the well, and a fluid entry means is moved into the well and located in a position correlated with said marker in accordance with the known relation of said marker and said production stratum, whereby said fluid entry means will coincide with said production stratum.

5. A method of producing fluid from the earth wherein a well intersects a production stratum, comprising: establishing a marker in proximity to and at a known distance from said production stratum independently of the computed distance of said production stratum from the top of the well; moving a fluid entry means into the well and locating the same in a position coinciding with said production stratum, said locating step being accomplished by placing said fluid entry means at said known distance from said marker independently of the computed distance of said production stratum from the top of the well.

6. A method of accurately positioning a member within a well with relation to a part of the well spaced at such distance from the top of the well that accuracy of measurements from the top of the well cannot be relied upon, comprising: establishing a marker in proximity to and at a known distance from the position desired for said member; moving said member into the well and locating the same in said desired position, by placing said member at said known distance from said marker independently of the computed distance of said desired position from the top of the well.

7. A method of accurately positioning a member within a well with relation to a part of the well spaced at such distance from the top of the well that accuracy of measurements from the top of the well cannot be relied upon, comprising: establishing a marker in proximity to and at a known distance from the position desired for said member; moving a marker locating means into the well to a known position relative to said marker; and then by using said known position of said marker locating means as a guide, placing said member at said known distance from said marker.

8. A method of accurately positioning a member within a well with relation to a part of the well spaced at such distance from the top of the well that accuracy of measurements from the top of the well cannot be relied upon, comprising: establishing a radio active marker in proximity to and at a known distance from the position desired for said member; moving a marker locating means which is responsive to radiations into the well to a known position relative to said marker; and then by using said known position of said marker locating means as a guide, placing said member at said known distance from said marker.

9. A method of accurately positioning a member within a well with relation to a part of the well spaced at such distance from the top of the well that accuracy of measurements from the top of the well cannot be relied upon, comprising: establishing a marker of magnetic material in proximity to and at a known distance from the position desired for said member; moving a marker locating means which is responsive to said magnetic material into the well to a known position relative to said marker; and then by using said known position of said marker locating means as a guide, placing said member at said known distance from said marker.

10. A method of producing fluids from the earth, comprising: forming a bore hole in the earth so that the same will intersect a plurality of production strata; placing a marker in proximity to each of said strata; setting a casing in the bore hole; locating said markers; and using said markers as guides, perforating said casing at selected production strata.

11. A method of exploring a well having a casing which intersects a production stratum, comprising: firing a projectile through a selected part of said casing to provide communication with an adjacent stratum, said projectile being so formed that it may be located by a locating device lowered into the well; making a test to determine if a desired fluid has entered said casing through the hole formed by said projectile; locating said projectile; and using the location of said projectile as a guide for the application of means to close said opening.

12. In means for perforating a casing in a well, the combination of: a perforator; means for moving said perforator within said casing; marker locating means connected to said perforator so as to move therewith; and means for actuating said perforator.

13. In means for perforating a casing in a well wherein a geophysical marker has been established in a known relation to a production stratum, the combination of: a perforator; means for moving said perforator within said casing; marker locating means comprising an electrometric strata logging device having a recording means outside the well and a testing element connected to said perforator so as to move therewith; and means for actuating said perforator.

14. In means for exploring a well, the combination of: electrometric means to indicate changes in and characteristics of strata in the earth; means for depositing a marker below the surface of the ground; and means for moving the aforesaid electrometric means and depositing means in correlation in the well.

15. In means for exploring a well, the combination of: electromagnetic means to indicate changes in the characteristics of strata in the earth; a gun of a size to move in said well; a radio active projectile carried by said gun; means for firing said projectile from said gun at a desired time; and means for moving said electrometric means and said gun in correlation in said well.

16. In means for accurately positioning a member in a well in which a marker has been established, the combination of: electrometric means for locating said marker, said electrometric means comprising a sensitive element adapted to be lowered into the well to the position of said marker and means outside said well to indicate to an observer when said sensitive element is positioned adjacent said marker; and means for moving in said well said sensitive element and the member which is to be positioned.

17. In means for cementing an opening in a well in which a marker has been established in a known relation to said openings, the combination of: electrometric means for locating said marker, said electrometric means comprising a sensitive element adapted to be lowered into the well to the position of said marker and means outside said well to indicate to an observer when said sensitive element is positioned adjacent said marker; cement applying means; and means for moving said cement applying means and said sensitive element, in correlative position, in said well whereby said marker may be first located and said cement applying means then positioned in a desired relation to said marker.

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SURVEYING CALIPER

Filed July 18, 1940 2 Sheets-Sheet 1

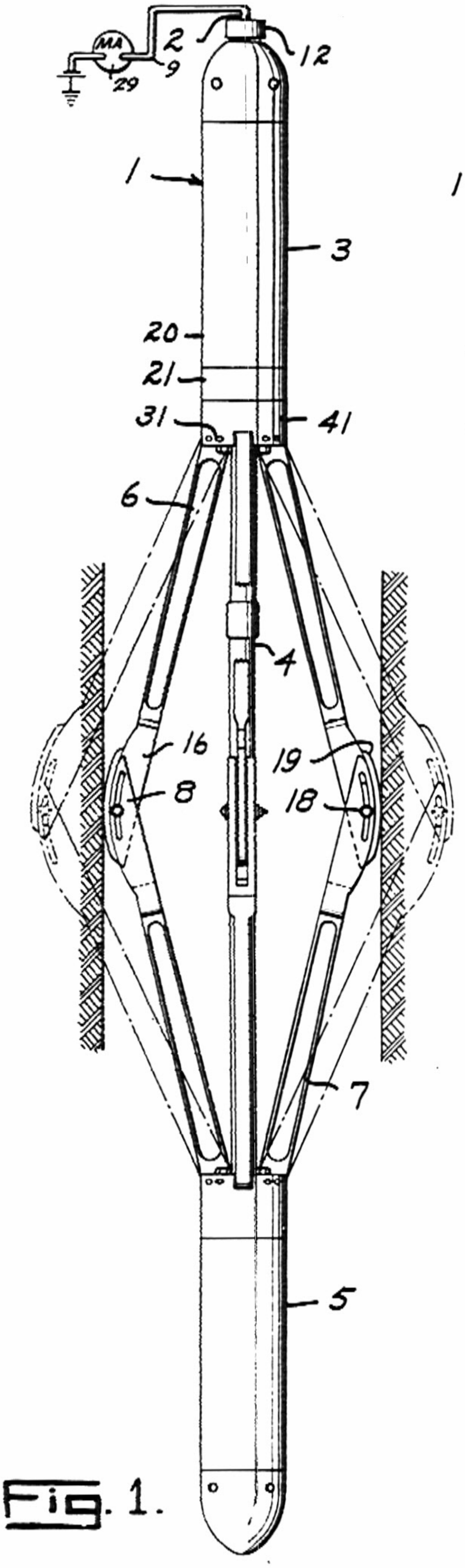

Fig. 1.

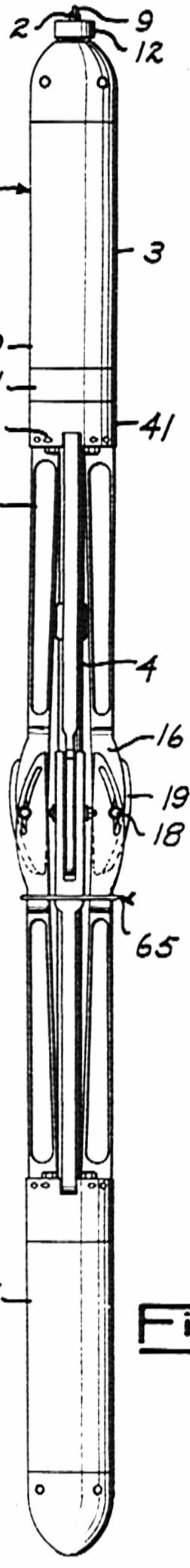

Fig. 2.

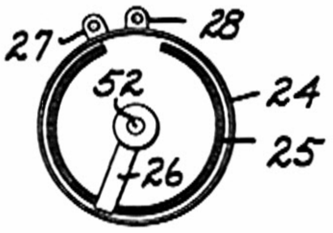

Fig. 9.

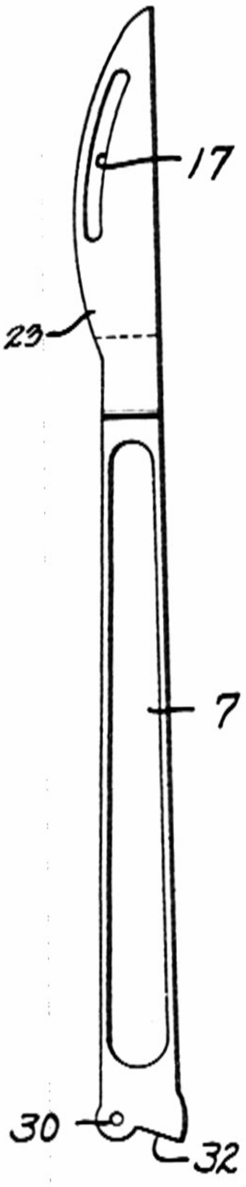

Fig. 3.

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SURVEYING CALIPER

Filed July 18, 1940 2 Sheets-Sheet 2

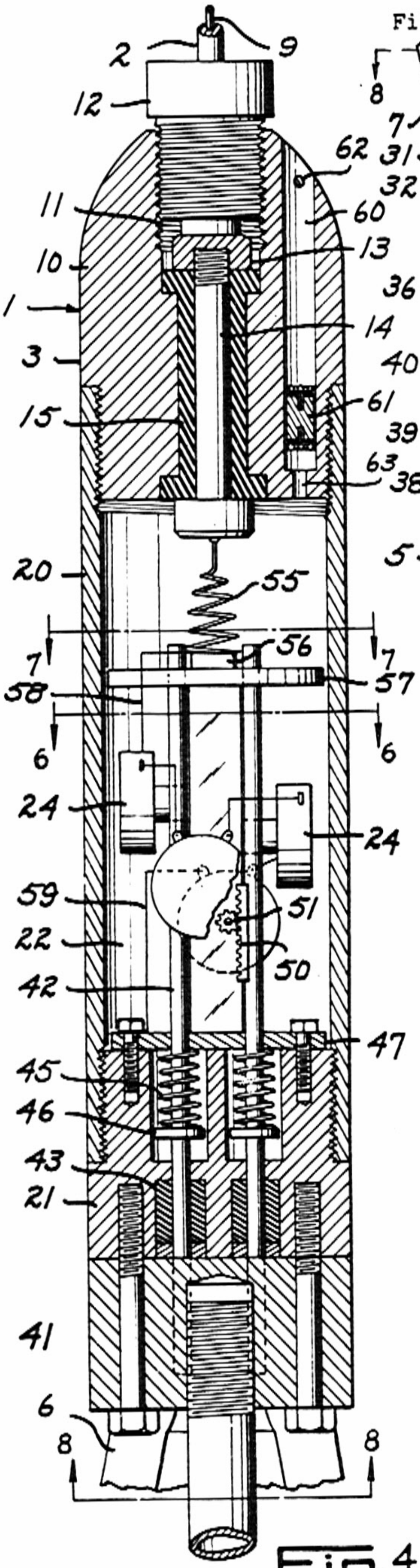

Fig. 4.

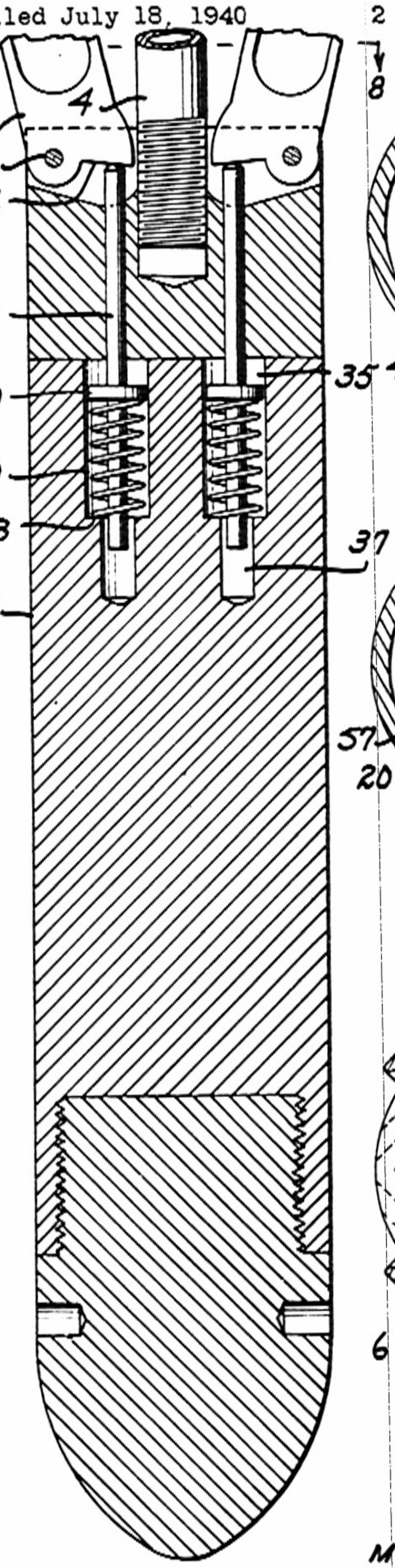

Fig. 5.

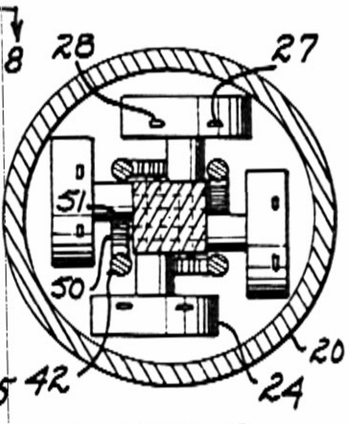

Fig. 6.

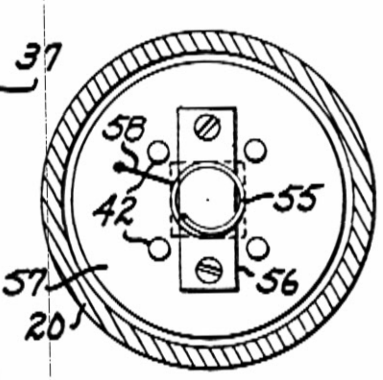

Fig. 7.

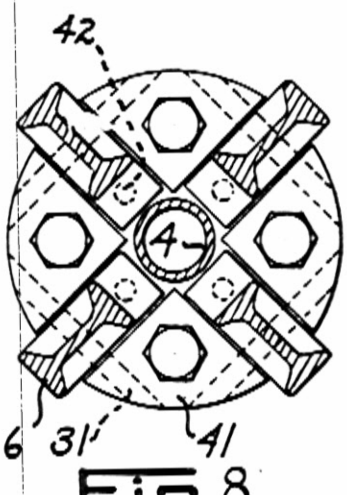

Fig. 8.

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UNITED STATES PATENT OFFICE

2,267,110

SURVEYING CALIPER

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Application July 18, 1940, Serial No. 346,116

11 Claims. (Cl. 33—178)

This invention relates to a device adapted to be moved within a bore to determine the variations in the cross sections thereof as the device is made to traverse the bore and is of particular utility in surveying well bores for determining the cross sectional area at all levels therein.

The invention relates to and comprises an improvement in well surveying device of the general type disclosed in my prior Patent No. 2,102,080 issued December 14, 1937.

The primary object of the invention is to provide a novel device for determining the size and shape of a well or like bore.

Another object is to provide an instrument of the class described which is capable of exhibiting at the mouth of the bore a continuous indication of the diametric variations in the bore hole as the device is moved therein.

Still another object is to provide a device which will give a continuous indication of diametric variations in a bore hole as the device is lowered into or elevated within the bore hole.

Another object is to provide a device having a plurality of feeler or caliper arms which are constantly urged radially outward into engagement with the walls of the well bore, mechanism being provided for instantaneous indications of the positions of such arms.

Another object is to provide a device which is lowerable upon a conductor cable and including an electric circuit within which the electrical conditions vary with and are indicative of the variations in the dimensions of the well bore.

Still another object is to provide a device including an electric circuit having variable resistors which vary with the movement of the caliper arms and hence give rise to variations in electrical conditions in such circuit, such variations being a measure of the diametric variations of the bore hole.

The foregoing objects together with other objects will be apparent from the following description taken in connection with the accompanying drawings in which:

Fig. 1 is an elevational view of a device embodying the invention and showing the relative position of parts when the device is within a bore hole;

Fig. 2 is an elevational view of the device with the caliper arms held inwardly so that the device may be readily transported;

Fig. 3 is an elevational view of one of the caliper arms;

Figs. 4 and 5 are vertical sectional views of successive portions of the device;

Fig. 6 is a transverse section taken on line 6—6 in Fig. 4;

Fig. 7 is a transverse section taken on line 7—7 in Fig. 4;

Fig. 8 is a sectional view taken on line 8—8 in Fig. 4;

Fig. 9 is a detail showing one of the resistors constituting an element of the device.

The device is generally referred to in the drawings as an assembly **1** which comprises a conductor cable **2** attached to the head **3** which is in turn attached by means of a rod **4** to a body member **5** at the lower end of the assembly. A plurality of pairs of feeler or caliper arms are attached to the head **3** and the body **5** and each of said pairs comprises an upper arm **6** and a lower arm **7** which are interconnected at their inner ends by a loose connection generally referred to as **8**.

As best seen in Fig. 4 the head **3** comprises a plug member **10** which is provided with a threaded bore **11** at its upper end to receive the connector **12** in which the conductor cable **2** terminates in such manner that the conductor **9** in the cable is electrically connected to the cap **13** attached to stem **14** passing through the insulator **15** extending downwardly from the bore **11**. This construction provides a mechanical connection between the cable **2** and the assembly **1** and also provides a fluid tight seal within the plug **10**.

A nipple **20** is threadably attached to the plug **10** and to a collar **21** to form a chamber **22** therebetween to receive a plurality of variable resistors **24** which are best shown in Fig. 9 and which comprise an annularly arranged resistance wire **25** over which a sliding contact **26** is movable so that the resistance between the terminals **27** and **28** may be varied to serve a function that will be more fully apparent.

Since the pairs of feeler arms are identical reference will be made to a single pair of these arms of which the upper and lower members **6** and **7** are provided at their outer ends with an opening **30** to reecive a pin **31** so that the arms are pivotally attached to the head and body members respectively. Adjacent the opening **30** in the arms there is provided a radially extending end surface **32** which is engaged by a spring pressed plunger within the head **3** on the body **5** to constantly urge the arms outwardly so that the inner ends of the arms will be pressed against the walls of the well bore as indicated in Fig. 1.

The inner end of the arm **7** is provided with bifurcations **23** to receive the flat inner end **16** of the arm **6**. The bifurcations **23** and the end **16** of the arms are provided with slots **17** through which a pin **18** passes to provide the loose connection **8** between the arms **6** and **7**. The arcuate outer surface of the end **16** is provided with a shoe **19** which is preferably of a wear resistant material so that the sliding contact of this portion of the arms with the wall of the well bore will not be rapidly abraded. It is to be noted that this arcuate construction, particularly in cooperation with the adjacent surface on the arms 6 and 7, enables movement of the assembly 1 either upwardly or downwardly within the bore hole and it is intended that the device when in use may be moved in either direction and observations may be made, as hereinafter set forth, regardless of the direction of the movement of the device.

The upper end of the body 5 is provided with bores 35 into which the lower end of plungers 36 extend. These bores are reduced in cross section at 37 to form a shoulder 38 upon which spring 39 rests. The opposite end of the spring engages a flange 40 on the plunger 36 so that the plunger is constantly urged upwardly in engagement with the surface 31 on the lower arm 7.

The upper end of the arm 6 is similarly attached to the block 41 at the lower end of the collar 21. However the upper plungers 42 pass through a packing 43 in the collar 21, such packing being provided to exclude the entrance to the chamber 22 along the plunger 42.

The spring 45 surrounding the plunger 42 engages the flange 46 on the plunger and also engages a guide plate 47 through which the plunger passes.

Above the plate 47 each of the plungers 42 is provided with a plurality of teeth 50 which mesh with a pinion 51 mounted upon the shaft 52 to which the contact arm 26 of the variable resistor 24 is attached. It seems apparent that by means of this construction the position of the contact arm 26 upon each of the resistors will depend upon the position of the associated pair of feeler arms.

In order to obtain the desired indication of the positions of the feeler arms a grounded electric circuit is provided so that the assembly 1 and the earth act as a conductor leading to the mouth of the bore hole. The other conductor for the circuit is shown as 9 in the conductor cable 2 and extends from the stem 14 through the spring 55 which is attached to an insulator block 56 mounted upon a guiding disk 57 through which the plungers 42 pass. The spring 55 is attached by means of a conductor 58 to one of the resistors 24, all of such resistors being connected in series and the last in the series being connected by means of conductor 59 to the body of the assembly.

While it has just been pointed out that the resistors 24 are preferably connected in series it is to be understood that other suitable connections of such resistors may be relied upon. It is also to be understood that the electric circuit also includes suitable mechanisms at the mouth of the bore hole, as for example a milliammeter 29, so that desirable indications in the circuit may be had as the device is made to traverse the bore hole. It is understood that any of suitable mechanisms available on the market for indicating the variations in electrical conditions in the electric circuit just described may be utilized. For example, known means may be used for constantly measuring the resistance of said such circuit, the drop of potential across the circuit, or the variations of current within the circuit when a constant potential is maintained thereon. Obviously other electrical characteristics of the circuit may be observed if desired. Electrical apparatus suitable for measuring electrical characteristics of the circuit is disclosed in the copending application of Finley T. Robidoux, Serial No. 419,215, filed November 14, 1941.

The plug 10 is provided with a longitudinal bore 60 within which is provided a piston 61 having sealing engagement with the walls of the bore and movable between the lower end of the bore and a retaining pin 62 at the upper end thereof. A passage 63 connects the bore 60 with the chamber 22, such chamber being filled with a suitable insulating liquid so that the entrance of well fluids to the interior of the chamber 22 and the mechanisms therein is effectively avoided. The volume of the chamber 22 varies slightly with the movements of the plungers 42 and the piston 61 moves in a manner to compensate for such variations in the volume of the chamber.

The operation of the device above described is believed apparent from the description. By way of summary it may be pointed out that during transportation of the device the pairs of arms are held inwardly as by means of a binding member shown as a wire 65 in Fig. 2. This wire is released preliminary to the lowering of the assembly 1 within the well bore. When the indicating instruments at the mouth of the well bore are properly adjusted the assembly is then lowered within the bore and the caliper arms are urged outwardly as disclosed so that the wear resistant shoes 19 on the upper arms 6 slidably engage the walls of the well bore. Observations are made or a record is produced of conditions in the electric circuit as the device is either lowered or raised within the well bore and in this manner it is possible to determine the diametric variations in the well bore whereby the object of the invention is realized. Broadly the invention comprehends a simple and novel construction for determining the size and shape of a well or like bore throughout the length thereof.

What is claimed is:

1. In a well surveying device for measuring the diametric variations in a bore hole the combination of a conductor cable, an assembly attached to said cable to be lowered into a well bore, said assembly comprising a head member attached to said cable and having a chamber therein, a body member in spaced relation with the head member, a plurality of pairs of interconnected arms having their outer ends pivotally attached to the head and body members respectively, a variable resistor mounted in said chamber for each of said pairs of arms, means operable by each of said pairs of arms for varying the resistance of one of the resistors, and an electric circuit including the resistors, a conductor in said cable and indicating means attached to the conductor at the mouth of the bore hole whereby the positions of the arms may be observed by the variations in electrical conditions in such circuit.

2. In a well sureying device for measuring the diametric variations in a bore hole the combination of a conductor cable, an assembly attached to said cable to be lowered into a well bore, said assembly comprising a head member attached to said cable and having a chamber therein, a body member in spaced relation with the head member, a plurality of pairs of interconnected arms having their outer ends pivotally attached to the head and body members respectively, a variable resistor mounted in said chamber for each of said pairs of arms, means operable by each of said pairs of arms for varying the resistance of one of the resistors, and

an electric circuit including the resistors, a conductor in said cable and indicating means attached to the conductor at the mouth of the bore hole whereby the positions of the arms may be observed by the variations in electrical conditions in such circuit, said chamber being filled with an insulating fluid to exclude well fluids from the chamber.

3. In a well surveying device for measuring the diametric variations in a bore hole the combination of a conductor cable, an assembly attached to said cable to be lowered into a well bore, said assembly comprising a head member attached to said cable and having a chamber therein, a body member in spaced relation with the head member, a plurality of pairs of interconnected arms having their outer ends pivotally attached to the head and body members respectively, a variable resistor mounted in said chamber for each of said pairs of arms, means operable by each of said pairs of arms for varying the resistance of one of the resistors, an electric circuit including the resistors, a conductor in said cable and indicating means attached to the conductor at the mouth of the bore hole whereby the positions of the arms may be observed by the variations in electrical conditions in such circuit, said chamber being filled with an insulating fluid to exclude well fluids from the chamber, a bore in said head communicating with the chamber therein, and a piston movable in said bore to compensate for variations in volume of the chamber.

4. In a well surveying device for measuring the diametric variations in a bore hole the combination of an assembly adapted to be lowered into a well bore, said assembly including spaced head and body members, there being a chamber in one of the members, a plurality of pairs of interconnected arms having their outer ends pivotally attached to the head and body members respectively, a plurality of variable resistors mounted in said chamber, means operable by each of said pairs of arms for varying one of said resistors, indicating means at the mouth of the bore hole, a conductor connected to said indicating means and extending downwardly in the well bore to said assembly, and an electric circuit including said resistors in series, said indicating means and conductor so that the variations in electrical conditons in said circuit by the movements of all of said arms is indicative of the diametric variations of the bore hole.

5. In a well surveying device the combination of a head member having a chamber therein, a body member, means attached to and holding said members in fixed spaced relation, paired arms pivotally attached to said members and having a slidable connection at the inner ends of each pair, spring pressed plungers mounted in said members and engaging and urging said arms radially of the members, and means operable by the movements of the plungers in the head member for indicating the movements of the arms.

6. In a well surveying device, a head member having a chamber therein, caliper arms pivotally attached thereto, means extending sealably outwardly from within the chamber and adapted to move in accordance with the movements of said arms, a liquid within said chamber, and means movable by said liquid to compensate for volumetric changes produced by the movements of said first mentioned means.

7. In a well surveying device the combination of a head member having a chamber therein and a body member secured in fixed spaced relation therewith, a plurality of pairs of arms having their outer ends pivotally attached to the head and body members respectively, a slidable connection between the inner ends of the arms of each pair, spring pressed plungers sealably passing through the wall of said chamber and engaging and urging the arms outwardly into engagement with the walls of a surrounding bore, a liquid within said chamber, a bore in said head communicating with the chamber therein, a piston movable in said bore whereby the liquid is retained within the chamber and the volume of the chamber is compensated for movement of the plungers, and means operable by the movements of the plungers for indicating the movements of the arms.

8. In a well surveying device, an elongated head member having a chamber therein and adapted to be lowered into a well bore, spring pressed members extending outwardly from within the head member, means movable by said spring pressed members into engagement with the walls of the well bore, a liquid filling said chamber to exclude well liquids from within the chamber, and movable means in contact with said liquid and the liquid within the well bore for maintaining a constant volume within the head member.

9. In a well surveying device, an elongated head member having a chamber therein and adapted to be lowered within a well bore, spring pressed members extending outwardly from within said member, means for moving said members in accordance with the diametrical variations in the bore hole, a liquid filling the chamber within the head member, a passage between the interior and exterior of the head member, and a piston movable in said passage, whereby the volume of the chamber is maintained constant and well liquids are excluded therefrom.

10. In a device of the class described an elongated body member, a chamber therein, there being passages between the interior and exterior of the member, said passages being counterbored at their inner and outer ends, a movable plunger in each of said passages, packing in each of the outer counterbores sealably surrounding the plunger therein, an abutment on each plunger in the inner counterbore and a spring in engagement with said abutment to normally urge the plunger outwardly.

11. In a device of the class described an elongated body member, a chamber therein, there being passages betwen the interior and exterior of the member, said passages being counterbored at their inner and outer ends, a movable plunger in each of said passages, packing in each of the outer counterbores sealably surrounding the plunger therein, an abutment on each plunger in the inner counterbore, a fixed guide plate for the plungers at the inner end of the passages, and a spring surrounding each plunger and engaging said guide plate and the abutment on the associated plunger to normally urge the plunger outwardly.

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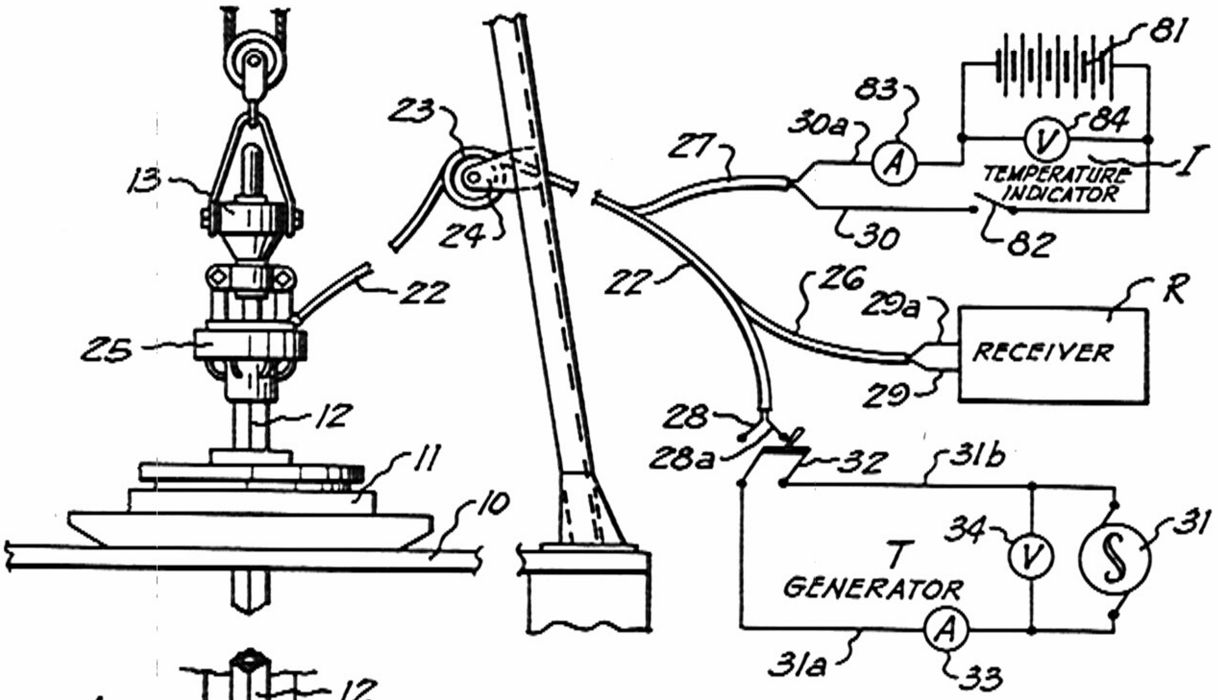
March 9, 1943. R. E. LEE **2,313,384**

MEANS FOR DETERMINING THE TECTONICS AND NATURE OF SUBSURFACE GEOLOGY

Filed April 28, 1939 4 Sheets–Sheet 1



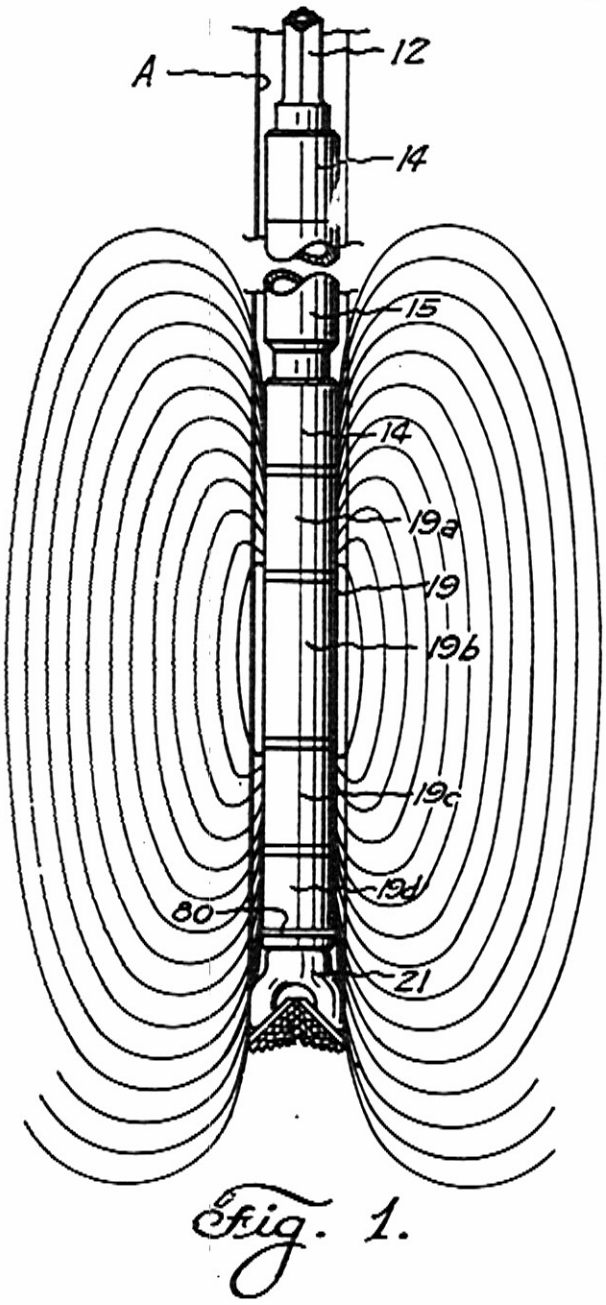


Fig. 1.

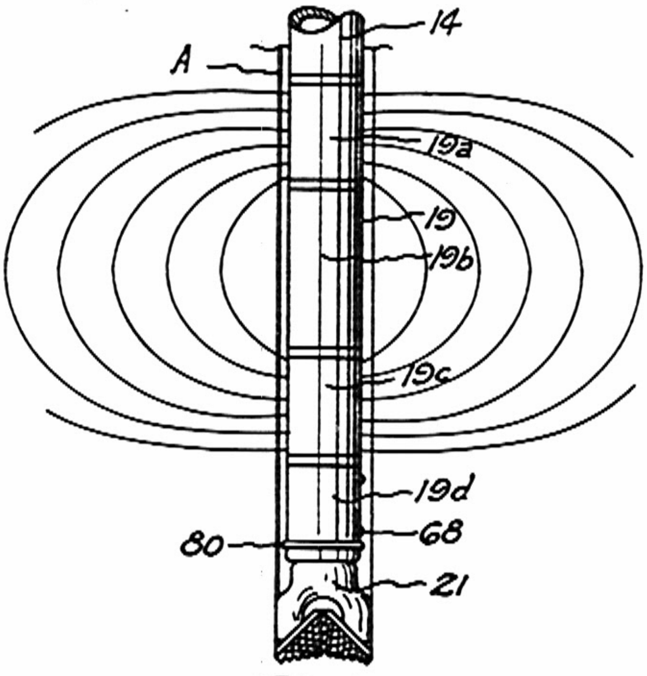


Fig. 9.

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MEANS FOR DETERMINING THE TECTONICS AND NATURE OF SUBSURFACE GEOLOGY

Filed April 28, 1939 4 Sheets-Sheet 2

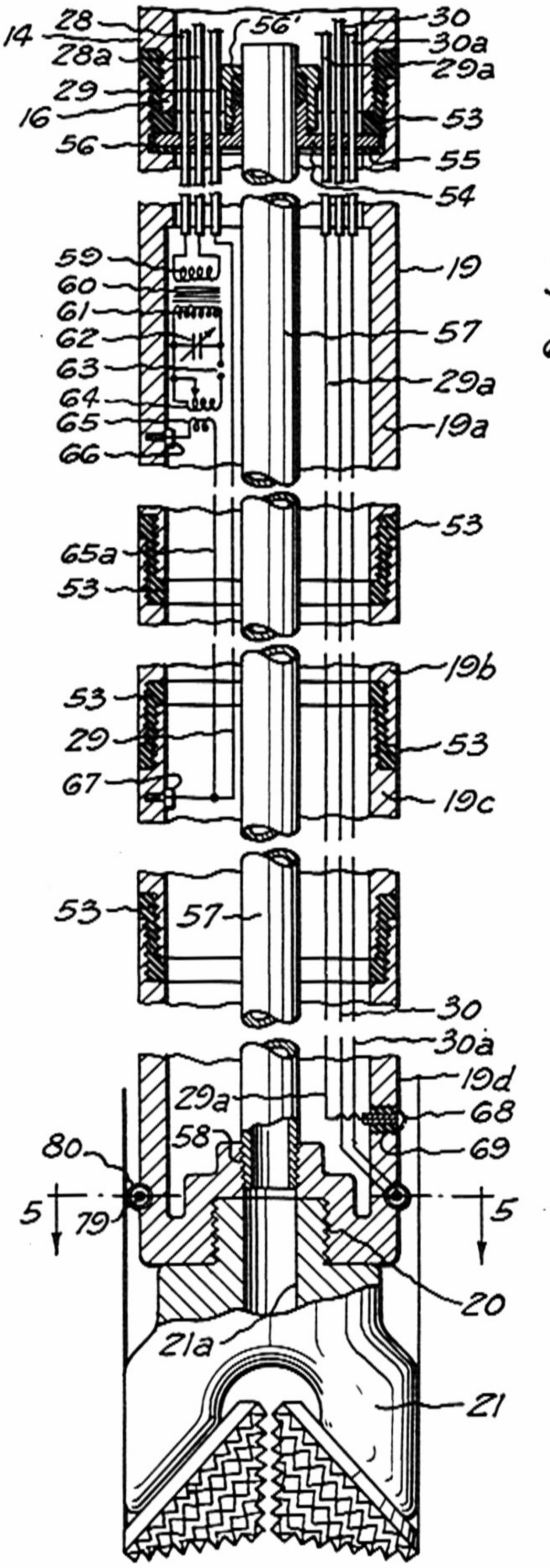

Fig. 2.

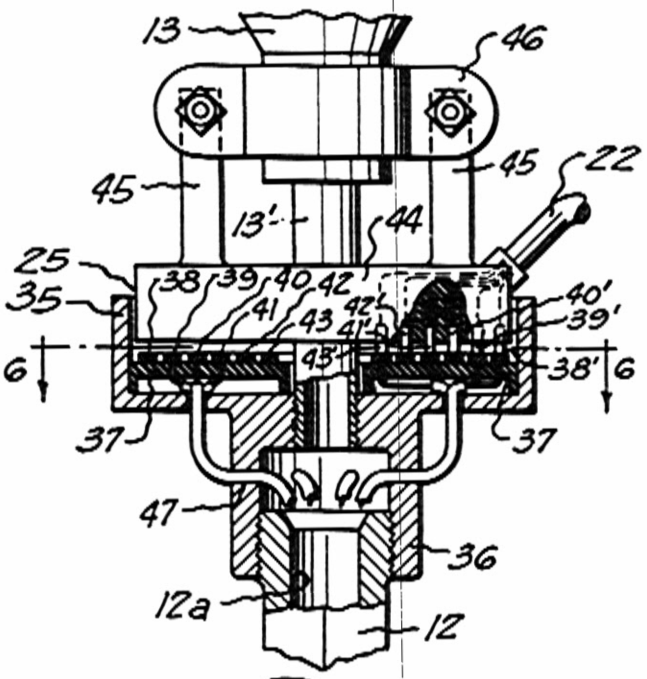

Fig. 3.

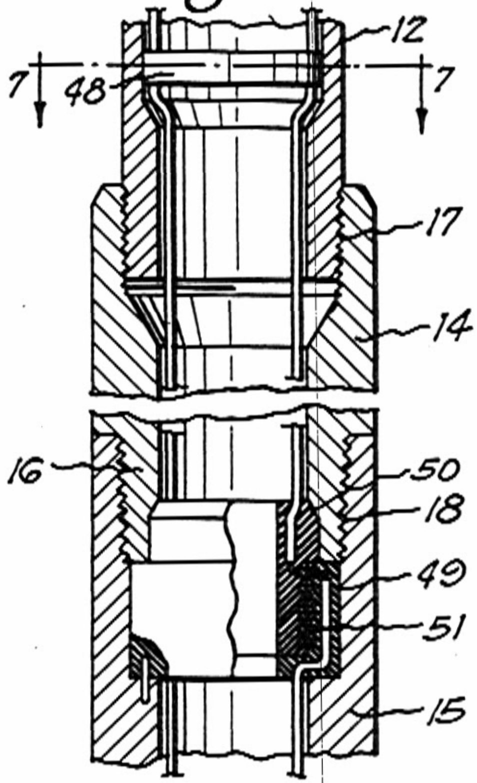

Fig. 4.

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MEANS FOR DETERMINING THE TECTONICS AND NATURE OF SUBSURFACE GEOLOGY

Filed April 28, 1939 4 Sheets-Sheet 3

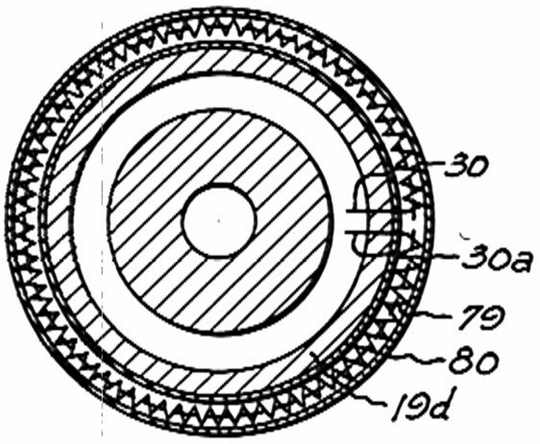

Fig. 5.

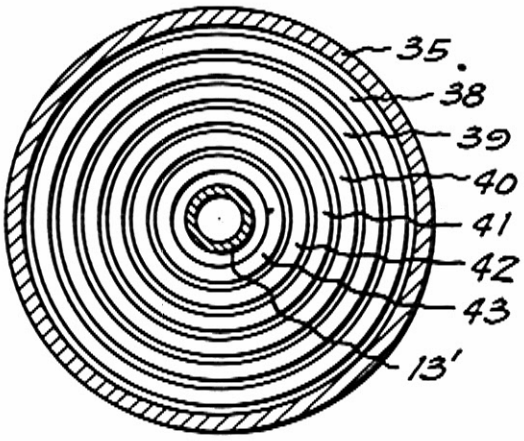

Fig. 6.

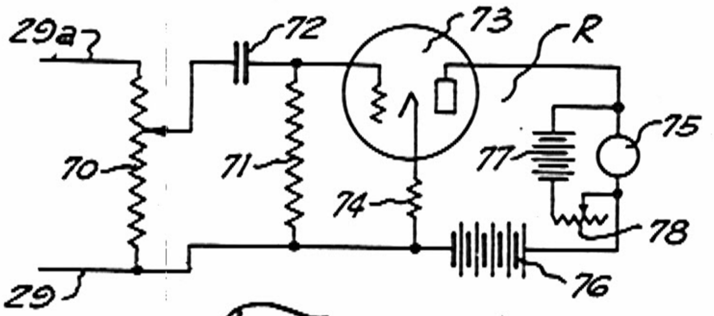

Fig. 8.

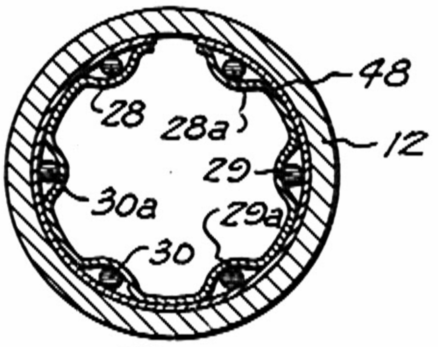

Fig. 7.

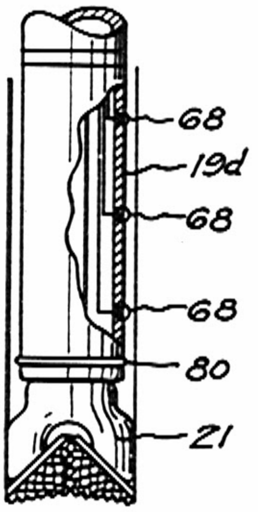

Fig. 10.

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MEANS FOR DETERMINING THE TECTONICS AND NATURE OF SUBSURFACE GEOLOGY

Filed April 28, 1939 4 Sheets-Sheet 4

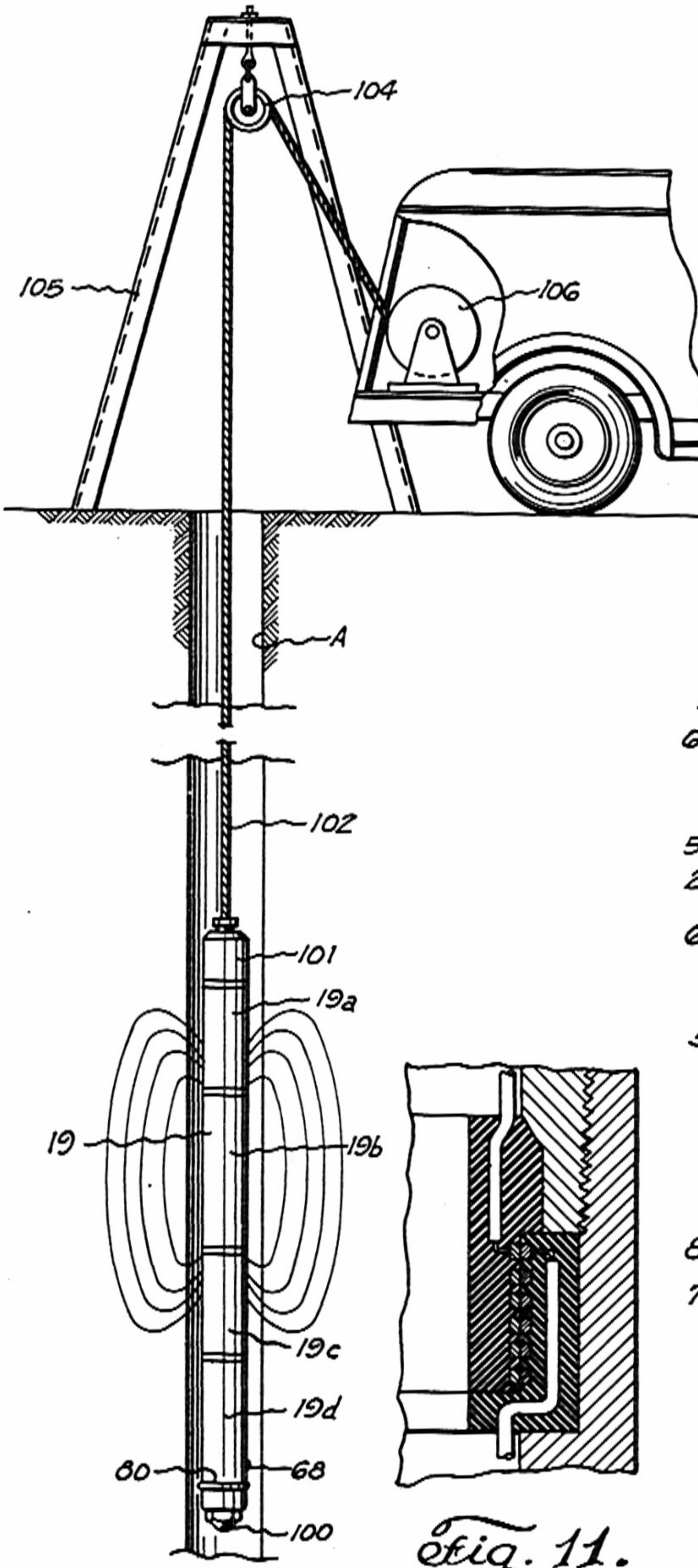

Fig. 12.

Fig. 11.

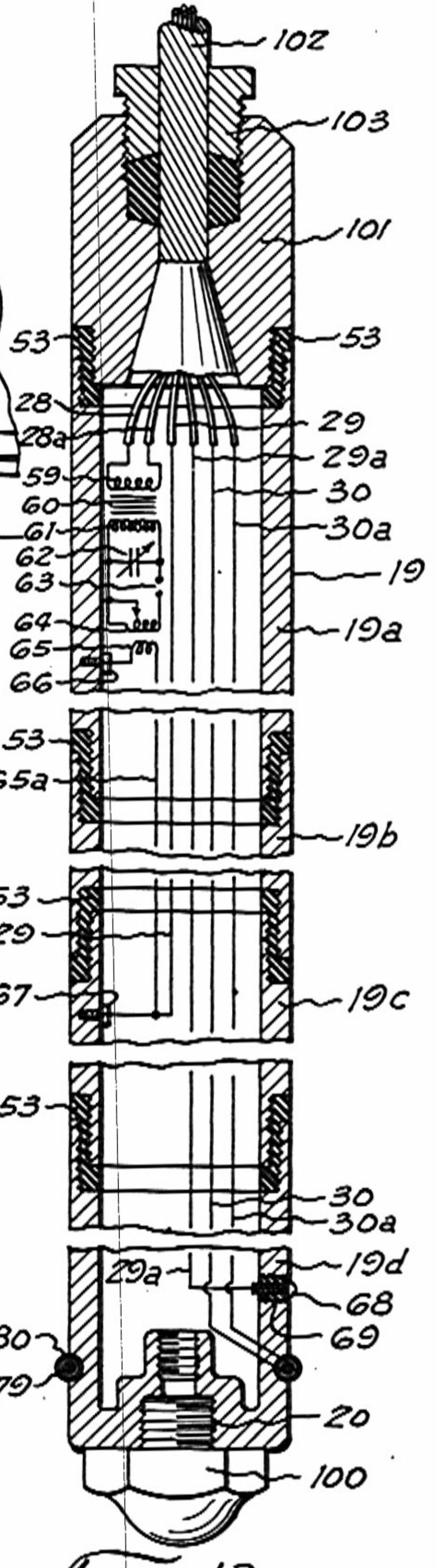

Fig. 13. Inventor
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Patented Mar. 9, 1943

2,313,384

UNITED STATES PATENT OFFICE

2,313,384

MEANS FOR DETERMINING THE TECTONICS AND NATURE OF SUBSURFACE GEOLOGY

Robert E. Lee, Coleman, Tex., assignor, by mesne assignments, to Joseph H. Reynolds

Application April 28, 1939, Serial No. 270,503

5 Claims. (Cl. 175—182)

This invention relates to new and useful improvements in means for determining the tectonics and nature of subsurface geology.

One object of the invention is to provide an improved method of geophysical survey whereby the tectonics and nature of the subsurface formations may be determined through the medium of an electrical current, either direct or alternating.

An important object of the invention is to provide an improved electrical method of geophysical survey which may be employed either during the drilling operation, or subsequent thereto, whereby the nature and structure of the formations in advance of the drilling tool, or immediately surrounding said tool, may be determined.

Another object of the invention is to provide an improved method of geophysical exploration, wherein temperature surveys are made of the formation being explored, in conjunction with electrical surveys, whereby additional data and bases are provided for accurate calibration to ascertain the resistivity, conductivity and salinity of the formation and thereby accurately determine the structure and nature of said formation.

Another object of the invention is to provide an improved method by which a continuous record may be obtained of the nature and tectonics of the formations traversed during the drilling operation, whereby an accurate log may be produced without the necessity of subsequent surveys.

A further object of the invention is to provide an improved method whereby the inherent terrestrial temperature of the formations may be ascertained so that said temperatures may be taken into consideration when determining the resistivity, conductivity and salinity of the formations, which assures more accurate information as to the structure of said formation.

A particular object of the invention is to provide an improved method, of the character described, wherein regional surveys may be made of formations as a bore hole is progressively surveyed, thereby enabling an operator to determine and locate nonconformities, lensing and shore line conditions, such as lenticular sands, in the subsurface geology.

Still another object of the invention is to provide an improved apparatus adapted to be associated with a rotating drilling tool, which is constructed so that the nature and tectonics of the subsurface formations surrounding, or in advance of the drilling tool, may be determined, whereby an accurate log of the underground structure may be produced.

A further object of the invention is to provide an improved apparatus for geophysical exploration, wherein the inherent terrestrial temperature of the formation is determined and also wherein the resistivity, conductivity and salinity of said formation is determined; such information yielding valuable information as to the underground structure.

Still another object of the invention is to provide an improved apparatus, of the character described, which will enable surveys to be made of wells being drilled with either rotary or cable tools, said apparatus permitting electrical and temperature surveys to be made during the actual drilling operation, or subsequent thereto.

A construction designed to carry out the invention will be hereinafter described, together with other features of the invention.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings, in which an example of the invention is shown, and wherein:

Figure 1 is an elevation of the apparatus, constructed in accordance with the invention, for performing the improved method, said apparatus being shown in a well bore,

Figure 2 is an enlarged, partial, transverse, sectional view of the lower portion of the apparatus,

Figure 3 is an enlarged view, partly in section and partly in elevation, showing the connection between the swivel and rotating drill stem,

Figure 4 is an enlarged, transverse, vertical, sectional view of one of the coupling elements between the drill stem sections,

Figure 5 is a horizontal, cross-sectional view, taken on the line 5—5 of Figure 2,

Figure 6 is a horizontal, cross-sectional view, taken on the line 6—6 of Figure 3,

Figure 7 is a horizontal, cross-sectional view, taken on the line 7—7 of Figure 4,

Figure 8 is a wiring diagram of the receiving and measuring circuit and instruments,

Figure 9 is an elevation of the lower portion of the drill stem and illustrating the general shape of the electrical field when generated into a formation of relatively low resistivity,

Figure 10 is a view, partly in section and partly in elevation, of a slightly modified form of the invention,

Figure 11 is an enlarged detail of the electrical connection at each tool joint, Figure 12 is an elevation of a modified form of the invention, illustrating the same lowered in a well bore, and

Figure 13 is an enlarged, transverse, vertical, sectional view of this modified form.

This application is filed as a continuation in part of my copending application filed March 28, 1938, Serial No. 198,546.

In the drawings, the numeral **10** designates the floor of a conventional derrick, on which the usual rotary table **11** is mounted. An angular drive member or kelly **12** extends through the rotary table and is arranged to be rotated thereby, the upper end of said kelly being supported by the usual swivel **13** which is suspended from the top of the derrick (not shown). The lower end of the kelly **12** is connected, by means of a coupling **14**, to the drill pipe **15**, which pipe extends downwardly through the well bore A. The coupling **14** is, in fact, a tool joint and, as is clearly shown in Figure 4, includes a pin section **16** provided with a threaded bore **17**, which bore is arranged to receive the lower screw-threaded end of the kelly **12**. The pin section **16** of the tool joint is adapted to be threaded into the socket of the usual tool joint box **18**. The box **18** is shown as formed integral with the upper end of each section of the drill pipe **15**, but if desired said box could be made separately and the drill pipe threaded into the lower end thereof. The various sections of the drill pipe are coupled together by means of the tool joint **14** and the lowermost section of drill pipe is connected with an elongate housing **19**, wherein the electrical surveying apparatus, as will be hereinafter described, is mounted. The lower end of the housing **19** is provided with an axial screw-threaded socket **20**, whereby a suitable drill bit **21**, of any desired construction, may be secured to said housing.

The kelly **12**, together with the drill stem **15**, housing **19** and drill bit **21**, are suspended from the swivel **13**, which swivel is, in turn, suspended from the top of the derrick. The provision of the swivel **13** permits a rotation of the kelly **12** when the rotary table **11** is revolved. A rotation of the kelly will rotate the drill pipe **15**, whereby the drill bit **21** is rotated to perform the drilling operation. This general arrangement is common practice in the well drilling art and has been shown and described merely for the sake of clarity.

The survey apparatus which is located within the housing **19** is electrically operated and it is necessary that electrical current be conducted downwardly to this apparatus. Also, it is necessary that readings or indications be taken at the surface and other lead wires must extend through the drill stem and kelly for this purpose. The lead wires which are necessary for the operation of the device are housed within a suitable cable **22** which is wound on a reel **23** carried by suitable supports **24**, as is clearly shown in Figure 1. The supports **24** are preferably secured to one of the derrick legs. One end of the cable **22** is connected to a commutator assembly **25** which is mounted on the upper end of the kelly **12**, as will be hereinafter explained. The other end of the cable **22** is connected with a transmitting or generating circuit T, which is shown schematically in Figure 1. The cable is provided with a branch lead **26** which has connection with a suitable receiver, as will be hereinafter explained. A second branch lead **27** extends from the cable **22** and has connection with a suitable temperature indicator I. The cable **22** and its leads **26** and **27** house six wires **28**, ***28a***, **29**, ***29a***, **30** and ***30a***. The wires **28** and ***28a*** have connection with the transmitter or generator T, the wires **29** and ***29a*** have connection with the receiver R, while the wires **30** and ***30a*** have connection with the temperature indicator I.

The transmitting circuit T includes a suitable source of electricity such as an alternating current generator **31**. It is noted, however, that any source of electrical current, either alternating or direct, may be employed. Lead wires ***31a*** and ***31b*** extend from the generator **31** and are arranged to be connected through a manually operated switch **32** with the wires **28** and ***28a*** which extend through the cable **22**. An ammeter **33** is connected in the wire ***31a*** and a volt meter **34** is positioned across the circuit, as is clearly shown in Figure 1. When the switch **32** is closed, the generator **31** will generate and transmit electrical current over the wires **28** and ***28a***, as will be hereinafter explained.

For making an electrical connection between the cable **22**, which is stationary, and the rotating drive element or kelly **12**, the commutator assembly **25** is provided. This assembly is clearly shown in Figure 3 and includes an annular housing **35**, which is formed with a depending collar **36**. The collar **36** is internally screw-threaded to receive the upper end of the kelly **12**. A commutator disk **37**, which is constructed of an insulating material, is mounted within the annular housing **35** so as to be rotatable therewith. This disk has a plurality of concentric contact rings **38**, **39**, **40**, **41**, **42** and **43** mounted thereon. The contact rings are arranged to be engaged by a plurality of spring-pressed brushes **38'**, **39'**, **40'**, **41'**, **42'**, and **43'**, which brushes are mounted within a circular block **44**. The block has its lower portion disposed within the annular housing **35** and is formed with upwardly extending arms **45** which are secured by means of a clamp **46** to the swivel **13**. A short pipe **13'** has its upper end connected to the swivel **13**, while its lower end is threaded into the collar **36** so as to communicate with the bore thereof, whereby drilling fluid may be circulated downwardly through the swivel, then through the pipe **13'** and into the kelly **12**.

With the arrangement of the commutator assembly, the block **44** which carries the spring-pressed brushes is fixed to the swivel and is nonrotatable. The contact rings which are carried by the commutator disk are rotatable with the annular housing **35** which is carried by the upper end of the rotating kelly **12**. Since the brushes are in constant engagement with the contact rings, it will be manifest that the electrical connection between the brushes and the rings will be maintained during rotation of the kelly or drive element **12**.

The cable **22**, which houses the six lead wires, as has been explained, is connected to the nonrotatable block **44**. The wires **28** and ***28a*** are connected to the brushes **38'** and **39'**, which brushes engage the outermost rings **38** and **39**. The wires **29** and ***29a***, which lead from the receiver, are connected to the brushes **40'** and **41'**, which brushes are in engagement with the contact rings **40** and **41**. The wires **30** and ***30a***, which lead from the temperature indicator I, are connected to the innermost brushes **42'** and **43'**, which brushes engage the rings **42** and **43**.

For conducting the current downwardly through the kelly **12** and through the drill stem and finally to the housing **19**, lead wires extend from the rings **38** to **43**. Since these wires are, in effect, a continuation of the six lead wires housed within the cable **22** and branch leads **26** and **27**, said wires have been given a corresponding number. Therefore, lead wires **28** and **28a** lead downwardly from the contact rings **38** and **39**, lead wires **29** and **29a** lead downwardly from the contact rings **40** and **41**, while the wires **30** and **30a** lead downwardly from the rings **42** and **43**. As is clearly shown in Figure 3, each of these wires extend through an opening **47** in the wall of the collar **36** and are then turned downwardly to extend through the bore **12a** of the kelly **12**.

The wires which extend downwardly through the kelly **12** are held against the wall of said kelly by a suitable split ring **48**, which ring is constructed of a spring metal. The ring is clearly shown in Figure 7 and serves to keep the wires separated from each other and in close proximity with the wall of the bore.

For making and continuing the electrical connection of the wires through the tool joint **14**, the bore of said tool joint is provided with a pair of contact members **49** and **50** (Figure 4). The member **49** is in the form of a collar which is disposed within the socket of the tool joint box **18**. A plurality of contact rings **51** are mounted in the bore of the collar **49** and the lead wires are connected to these rings. The member **50** is in the form of a block and has a plurality of contact rings on its outer surface, which rings are connected to the wires passing downwardly through the drill stem. When the tool joint is made up, the block **50** is moved into the collar **49**, whereby the contact rings of these two members are moved into registration and engagement with each other, whereby when the joint is completely made up, an electrical connection is established therethrough.

The lowermost section of the drill pipe **15** is connected into the pin section **16** of the lowermost tool joint **14**. This pin section is, in turn, threaded into the upper end of the housing **19**, as is clearly shown in Figure 2. A suitable insulating bushing **53**, preferably constructed of a non-ferrous insulating material, is interposed between the pin section **16** and said housing, whereby the housing is insulated from the drill stem **15**. A transverse plate **54** is clamped between the end of the pin section **16** and a shoulder **55** formed within the upper end of the housing **19** and this plate rests on a suitable sealing ring **56**, whereby the periphery of the plate is in fluid-tight engagement with the wall of the housing. A stuffing box **56'** extends upwardly from the plate and has the upper end of a tubular conductor **57** extending therethrough. The conductor **57** extends axially through the housing **19** and has its lower end threaded into an opening **58** which is provided in the bottom of said housing. The opening **58** communicates with the bore **21a** of the drill bit **21** and, manifestly, a drilling fluid, which may be circulated downwardly through the drill stem **15**, may flow through the conductor **57** and to the bit **21** in order to lubricate the cutting element of said bit. Since the partition **54** has its peripheral portion sealed, it is evident that the drilling fluid cannot pass downwardly into the interior of the housing **19**. The wires **28**, **28a**, **29**, **29a**, **30** and **30a**, which lead from the unit at the surface, pass through suitable openings in the plate **54**, whereby the lower ends of said leads extend into the interior of the housing **19**. It is noted that suitable packing elements may be disposed within the openings in the plate and around the lead wires to prevent the drilling fluid from passing into the housing **19**.

The housing **19** is constructed of four sections **19a**, **19b**, **19c** and **19d**. The sections **19a**, **19b** and **19c** are tubular and are coupled together by threaded engagement. Each section is insulated from the other by means of one of the insulating bushings **53**, whereby each section is electrically insulated from the other. The uppermost section **19a** forms an oscillator zone, while the third section **19c** provides a lower or current return zone, the intermediate section **19b** serving as an insulating neutral zone between the oscillator zone and the return zone. The lowermost section **19d** is, of course, connected to the section **19c** and has its lower end directly connected to the drill bit **21**, as has been explained. The entire intermediate section **19b** may be constructed of an electrical insulating or non-ferrous material to assure its insulation from the other sections.

The electrical apparatus, which is housed within the housing **19**, has been shown schematically and, as explained, the lead wires from the surface extend downwardly into the interior of the housing. Referring to Figure 2, it will be seen that the wires **28** and **28a**, which wires lead from the generator T, are connected to the primary coil **59** of a transformer which is mounted within the upper section **19a** of the housing. The purpose of the transformer is to change the low voltage alternating current into a high voltage alternating current. The transformer includes the usual core **60** which is interposed between the primary coil and a secondary coil **61**. A variable condenser **62** is arranged across the secondary circuit of the transformer and said secondary circuit also includes a fixed spark gap **63** and a variable inductance coil **64**. If desired, a vacuum tube of suitable construction may be substituted for the spark gap. A coupling coil **65** is connected to a contact **66**, which contact is threaded into the wall of the section **19a**. This latter coil also has connection through a wire **65a** with a second contact **67** which is threaded into the third section **19c** of the housing and, with this arrangement, it will be obvious that the contacts **66** and **67** which are connected to the coupling coil **65**, are insulated from each other being separated by the intermediate section **19b** which is insulated from the sections **19a** and **19c**. The contacts **66** and **67** also have connection with the wire **29** which leads downwardly through the plate **54**. It is noted that the upper end of the wire, after passing through the commutator assembly **25**, extends through the cable **22** and then through the lead **26** and finally connects to the receiver R.

The other lead wire **29a** of the receiver R extends downwardly through the cable **22** and then through the drill stem **15**, as explained, and into the interior of the housing **19**. This wire, as is clearly shown in Figure 2, extends downwardly through the sections **19b**, **19c** and into the interior of the lowermost section **19d** of the housing. The wire has connection with a metallic contact **68**, which contact has its outer end exposed to the exterior of the housing. The contact **68** is mounted within a bushing **69**, which is constructed of an insulating material, whereby said contact is insulated from the section **19b**.

The receiver R, which is connected to the lead wires **29** and **29a** extending from the contacts

67 and 68, respectively, is schematically shown in Figure 8. The receiver comprises a square law vacuum tube voltmeter and the lead wires 29 and 29a are connected to a variable resistance 70. A resistance 71 is arranged across the circuit, with a condenser 72 being interposed between the resistances 70 and 71. A vacuum tube 73 is connected in the circuit, being connected in parallel to the above described circuit through a resistance 74. A recording milliammeter 75 is also connected in the circuit, which circuit is supplied with direct current by a battery 76. A bucking battery 77 is connected across the milliammeter and its circuit includes a variable resistance 78. The purpose of the variable resistance is to enable an operator to neutralize the effects of terrestrial magnetism and the electrical phenomena inherent in the region which is being explored, as will be explained.

From the foregoing, it will be seen that the lead wires 28 and 28a serve to conduct an electrical current downwardly through the transformer and to the region being explored, whereby an electrical field will be generated in the subsurface formation surrounding the drill stem. The lead wires 29 and 29a serve to operate the receiver R at the surface to indicate the effect of the electrical field which is set up in the formation. The lead wires 30 and 30a which lead from the temperature indicator I extend downwardly through the drill stem 15 and through openings in the plate 54, the lower ends of said wires extending downwardly through the sections of the housing 19. The lower ends of the wires 30 and 30a are connected with a thermoresistance coil 79, which coil surrounds the lower end of the section 19d of the housing (Figures 2 and 5). The coil is constructed of an insulated wire which is disposed within a hermetically sealed annular chamber or tube 80. As explained, the upper ends of the wires 30 and 30a are connected to the circuit of the temperature indicator I, which is diagrammatically shown in Figure 1. This circuit includes a battery 81, or other source of direct current, which battery has its opposite sides connected to the wires 30 and 30a. A suitable manual switch 82 is connected in the wire 30, while an ammeter 83 is connected in the wire 30a. A voltmeter 84 is arranged across the circuit, as illustrated.

It is well known that the resistance of an insulated thermoresistance coil will vary with the temperature of the surrounding medium and, therefore, if the temperature surrounding the coil is higher, a different resistance is had than if a lower temperature is present around said coil. According to Ohm's law, the readings of the voltmeter 84 and the ammeter 83 in the indicating circuit I, which vary with the resistance of the coil 79, will indicate the temperature adjacent said coil. Thus, by observing the ammeter and voltmeter in the circuit I, it is possible to determine the resistance of the coil 79 and thereby arrive at the temperature in the well bore adjacent said coil.

It is also well known that the temperature of matter affects its electrical conductivity or resistivity. Therefore, in passing an electrical current through a body, its is desirable to know the temperature of that body in order to properly calibrate the conductivity or resistivity thereof. For this reason, the provision of the thermoresistance coil 79 makes it possible for the operator to know the temperature within the bore surrounding the coil at all times. When the operator determines this temperature, he can utilize the information to properly calibrate the conductivity or resistivity of the surrounding formation, as will now be explained.

In practicing the improved method with the apparatus disclosed herein, the bit is first lowered into the bore and the calculations may be made during the drilling operation. When a reading is to be taken, the first reading is that of the temperature indicator I. This reading is taken while the drill bit is at rest and is not under rotation. The indication which is obtained will indicate the inherent terrestrial temperature and such indication is noted. The temperature of the drilling fluid which is being circulated downwardly through the drill stem and upwardly through the bore outside of said drill stem is then determined. This temperature, as it affects the temperature of the bore adjacent the housing 19, will be indicated by the differential between the temperature of the drilling fluid which is introduced into the upper end of the kelly 12 and the temperature of the drilling fluid as it escapes from the upper end of the bore. By noting this temperature differential, the operator can determine the heat transfer which occurs through the circulating drilling fluid and the formation which it contacts during its circulation. In other words, if the drilling fluid is introduced into the kelly at one temperature and is discharged from the upper end of the well bore A at a higher temperature, this will indicate to the operator that the highest temperature within the bore is approximately that of the discharging drilling fluid, and such highest temperature ordinarily is at the bottom of the bore. Thus, the operator can take into consideration the temperature rise or drop in the fluid which is brought about by the circulation of the drilling fluid.

After the indications on the indicator I, and the temperature differential of the circulating fluid, have been noted, the rotary table 11 may be rotated to rotate the kelly 12. Such rotation will result in a rotation of the drill stem 15 and a rotation of the drill bit 21, whereby the drilling operation is performed. It is obvious that the rotation of the drill bit, as it engages the formation to perform the drilling operation, will create a friction which will result in additional heat at the bottom of the well bore. Such heat which is the result of the friction will, of course, act upon the thermoresistance coil 79 to change the indication or reading on the indicator I. By noting such change in the indicator reading, and keeping in mind the previous reading, as well as the temperature differential in the circulating fluid, the operator may readily calibrate the inherent terrestrial temperature of the medium or media which is adjacent the drilling bit. Therefore, as the bit moves downwardly through the various formations traversed by the well bore A, the operator is at all times advised of the inherent terrestrial temperature of said formations as the bit moves therethrough.

To determine the nature of the formation adjacent the housing 19, the switch 32 of the generator T is closed so as to connect said generator with the wires 28 and 28a. When this occurs, an electrical current is conducted to the primary coil 59 of the transformer, which is located in the upper section 19a of the housing 19. The transformer acts to increase the voltage to a predetermined degree and a high frequency is obtained through the medium of the variable condenser **62**, spark gap **63** and variable inductance coil **64**. It is noted that the setting of the variable inductance is predetermined and is held constant throughout the survey, whether such survey is made during the drilling operation or is made subsequent thereto.

As has been explained, the coupling coil **65** is connected to the electrical contacts **66** and **67**, which contacts are mounted or connected with the sections **19***a* and **19***c* of the housing, said contacts being separated by the insulated section **19***b*. Thus, it will be seen that a current of high frequency of predetermined characteristics is propagated and imposed upon the media surrounding the neutral zone, that is, that zone occupied by the intermediate section **19***b*. The propagation of this high frequency current forms an electrical field, as is schematically illustrated in Figures 1 and 9, and the characteristics of this field are relative to the conductivity, resistivity and salinity of the surrounding media. It is pointed out that by varying the length of the section **19***b*, the size of the electrical field may be varied to cover more or less area. To avoid setting up a field between the section **19***a* and the drill stem, the lowermost sections of said stem may be of insulating or non-ferrous material.

It is well known that when an electric field is set up within a media, the electric field pattern s dependent upon the character or nature of said media. In other words, if the media is of high resistivity and low conductivity, the field pattern will be as illustrated in Figure 1, with the lines of force extending vertically rather than radially outwardly from the bore. If the media s of a high conductivity and low resistivity, such as a porous formation saturated with salt water, hen the electrical field pattern will be as shown n Figure 9, with the lines of force extending a elatively far distance outwardly from the bore. Thus, it will be seen that the field pattern which occurs when the electrical field is formed varies with the particular formation or strata which is adjacent the point of generation.

Referring again to Figure 1 which illustrates the field pattern when the neutral zone is surounded by a media of high resistivity, it will be observed that the electrical lines of force are arranged to engage the metallic contact **68**. This contact, as has been explained, is connected y the lead wire **29***a* to the receiver R. Consequently, distortion of the lines of force will impose change in voltage on the receiver circuit, which distortion will vary as a function thereof. Therefore, when the lines of force are as shown in Figure 1, the intensity of the electrical field adjaent the contact **68** is much greater than it is when the field pattern is as in Figure 9, with the esult that an indication on the milliammeter **75** f the receiver will indicate the distortion of the lines of force or the electrical field pattern. When the field pattern is as in Figure 1, it is obvious that the electrical lines of force, under certain conditions, will penetrate media below the earth boring tool, and hence surface indicaions may be made relative to the strata to be ncountered as drilling proceeds. Manifestly, when the field pattern is known, this indicates the penetration of the electrical lines of force radially through the strata or formations, wherey the nature and tectonics of said formations may be determined. When the inherent terresrial temperature, as previously determined by means of the thermoresistance coil **79** and the indicator I, is considered along with the particular field pattern which is set up, an accurate knowledge of the nature and characteristics of the formation being explored may be obtained. As the temperature varies, so does the resistivity and conductivity of a particular formation vary. With the method and apparatus herein described, all of the conditions, which enter into an electrical survey of the formations, are ascertained, whereby an accurate survey is possible. It is noted that the field pattern is determined directly at the zone being surveyed which makes for more accurate information; also the survey may be made while the drilling operation is being performed or, if desired, the survey may be made while the drill bit is inactive and subsequent to the drilling.

In Figure 10, a slightly modified form of the invention is shown. It may be that in some instances and under certain conditions, that a single contact **68** would be insufficient to provide an accurate reading on the receiver. In such cases, it would be possible to provide a plurality of the contacts **69**, which contacts are mounted in the wall of the lowermost section **19***d* of the housing **19**. Each contact **68** would be connected to an individual receiver (not shown) and, by noting the readings, as affected or controlled by each contact, a more accurate indication of the distortion of the field pattern could be obtained. Thus, it will be seen that the invention is not to be limited to the use of a single contact **68** as any desired number may be employed.

As before stated, the method may be performed either during the drilling operation and while the drill bit is rotating, or subsequent thereto. The electrical and temperature surveying unit, herein described, may be operated in a bore hole which has been previously drilled by means of a cable instead of a drill stem, the units of the circuit being encased within the cable, insulated from each other and from the cable.

In Figures 1 to 11, the invention has been shown and described as applied to a drill stem and bit, whereby surveys may be made during or subsequent to the drilling operation. However, it is noted that, if desired, the housing **19** may be a separate unit and may be lowered through a pre-drilled bore hole on a wire line or cable. Such an arrangement is clearly shown in Figures 12 and 13, wherein the housing **19** and its associate parts are of substantially the same construction. However, in this form, the lower end of the housing is closed by a bull plug **100** which is threaded into the axial opening **20** in the bottom of said housing. The upper end of the housing has a cable socket **101** threaded thereinto and a cable **102** has its lower end secured within the socket in the usual manner. A packing gland **103** surrounds the cable and is located within the upper end of the socket for packing off around said cable. In this form, the vertical pipe or conductor **57**, as well as the transverse partition **54**, are omitted and the various lead wires **28**, **28***a*, **29**, **29***a*, **30** and **30***a* are housed within the cable **102**.

The cable extends upwardly from the well bore and passes over a pulley or sheave **104** which is suspended from the derrick or from a tripod **105** provided for the purpose. The cable is wound on a suitable reel or drum **106** which may be stationary, or which may be mounted on a truck, or other vehicle, as illustrated. When the reel is supported on a vehicle, the transmitting, receiving and indicating instruments and equipment are mounted within the truck. The operation of this form is exactly the same as the form, wherein the apparatus is connected in the drill stem. The cable supported unit involves less time in making the surveys for it may be lowered and raised much more quickly. In both instances, an electrical field is set up in the formation adjacent the unit and the measurement of the distortion of said field is taken at the field, rather than at a point remote therefrom.

The foregoing description of the invention is explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made, within the scope of the appended claims, without departing from the spirit of the invention.

What I claim and desire to secure by Letters Patent is:

1. An apparatus for geophysical exploration including, a housing adapted to be connected in a drill stem, means carried by the housing for setting up an electrical field within the media surrounding said housing, a receiver at the surface, and means mounted on the housing effected by the electrical field and connected with the receiver for indicating the physical distortion of the electrical field pattern as caused by the nature and characteristics of the formation.

2. An apparatus for geophysical exploration including, a housing adapted to be connected in a drill stem, means for conducting an electrical current to the housing to set up an electrical field within the media surrounding said housing, a receiver at the surface, means on the housing effected by the electrical field and connected with the receiver for indicating the physical distortion of the electrical field pattern as caused by the nature and characteristics of the formation, means carried by the housing and effected by the temperature surrounding the same, and means at the surface for indicating the temperature variations as they effect said means.

3. An apparatus for geophysical exploration including, a housing adapted to be connected in a drill stem, means for conducting an electrical current to the housing to set up an electrica field within the media surrounding said housing a receiver at the surface, means on the housin effected by the electrical field and connected wit the receiver for indicating the physical distortio of the electrical field pattern as caused by th nature and characteristics of the formation, thermoresistance coil carried by the housing, an electrical means connected with said coil for indicating changes in its resistance as caused b temperature changes in the bore.

4. An apparatus for geophysical exploratio including, a housing adapted to be connected i a drill stem, means carried by the housing fo setting up an electrical field within the medi surrounding said housing, means for conductin an electrical current to the last named means fo actuating the same, means mounted on the hous ing adjacent the media in which the electrica field is set up for determining the physical distortion of the electrical field pattern, and indicatin means at the surface connected with the determining means for visibly indicating the distortio of the field as affected by the nature and characteristics of the formation.

5. An apparatus for geophysical exploratio including a housing adapted to be connected i a drill stem, means carried by the housing fo setting up an electrical field within the medi surrounding said housing, means for conductin an electrical current to the last named means fo actuating the same, means mounted on the hou ing adjacent the media in which the electric field is set up for determining the physical di tortion of the electrical field pattern, indicati means at the surface connected with the dete mining means for visibly indicating the disto tion of the field as affected by the nature a characteristics of the formation, means mount on the housing for determining the terrestri temperature of the formation, and means at t surface for indicating such temperature as d termined by the last named means.

ROBERT E. LEE.

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METHOD AND APPARATUS FOR DETERMINING WATER LEAKAGES INTO WELLS

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Fig. 1

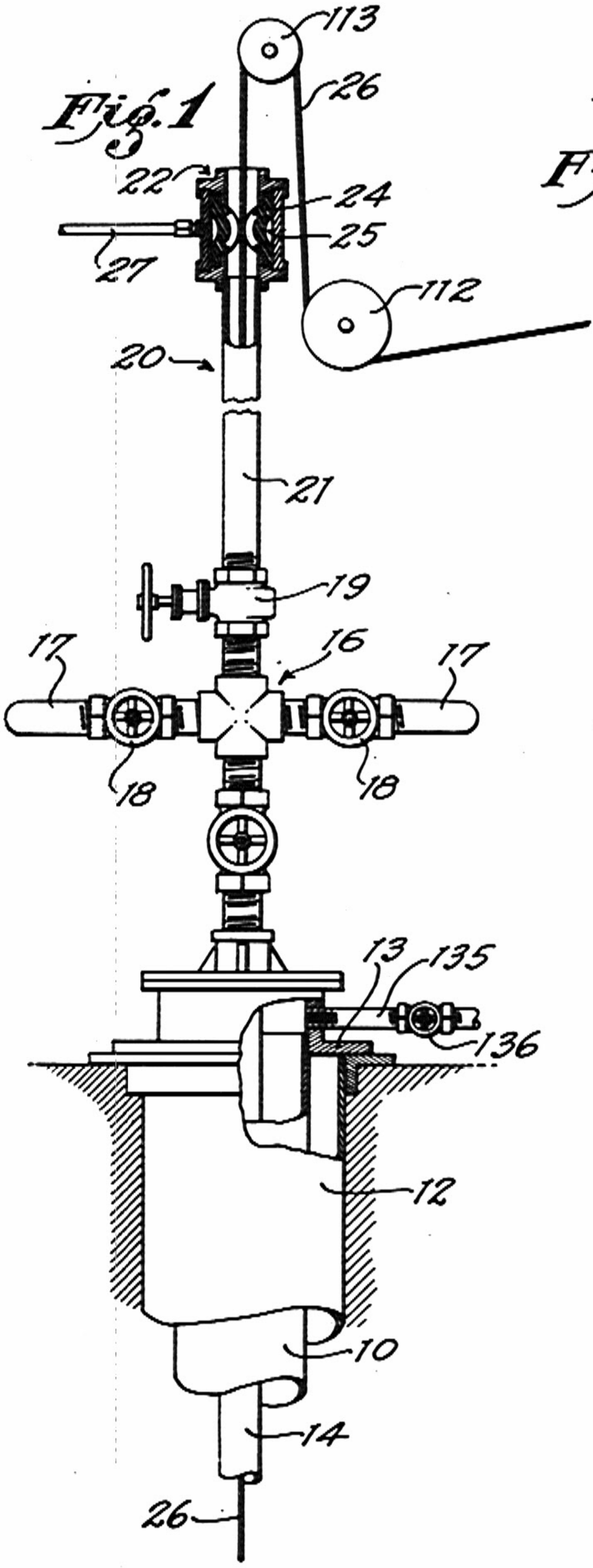

Fig. 2

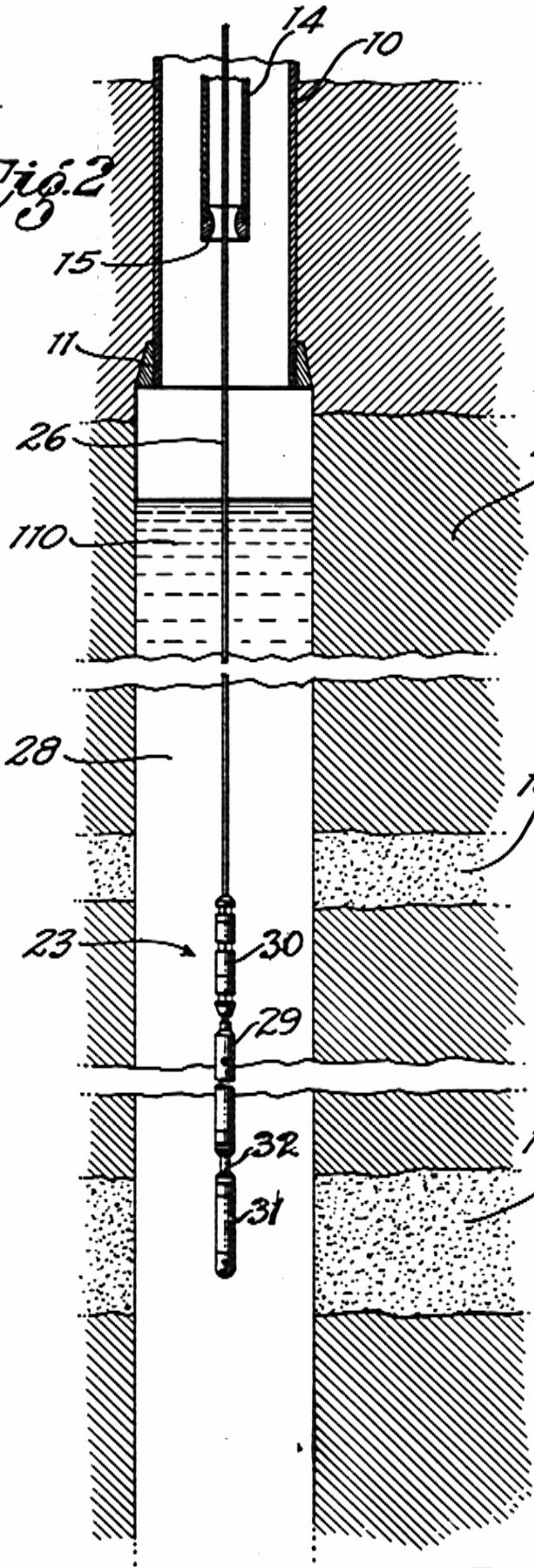

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Fig. 4

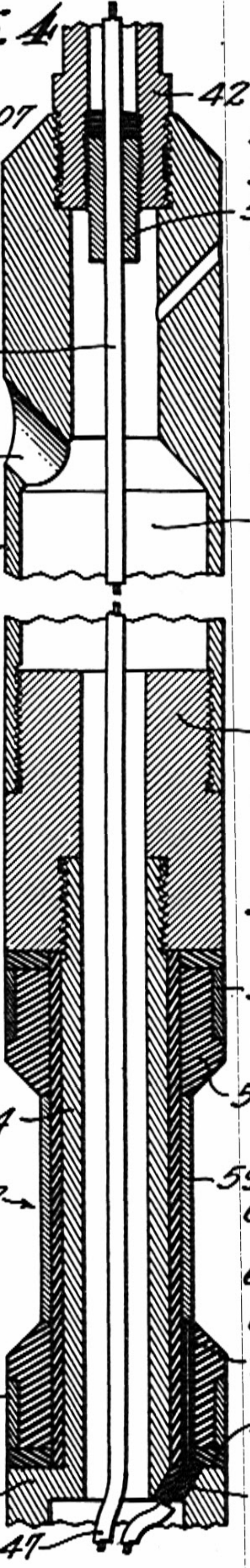


Fig 5

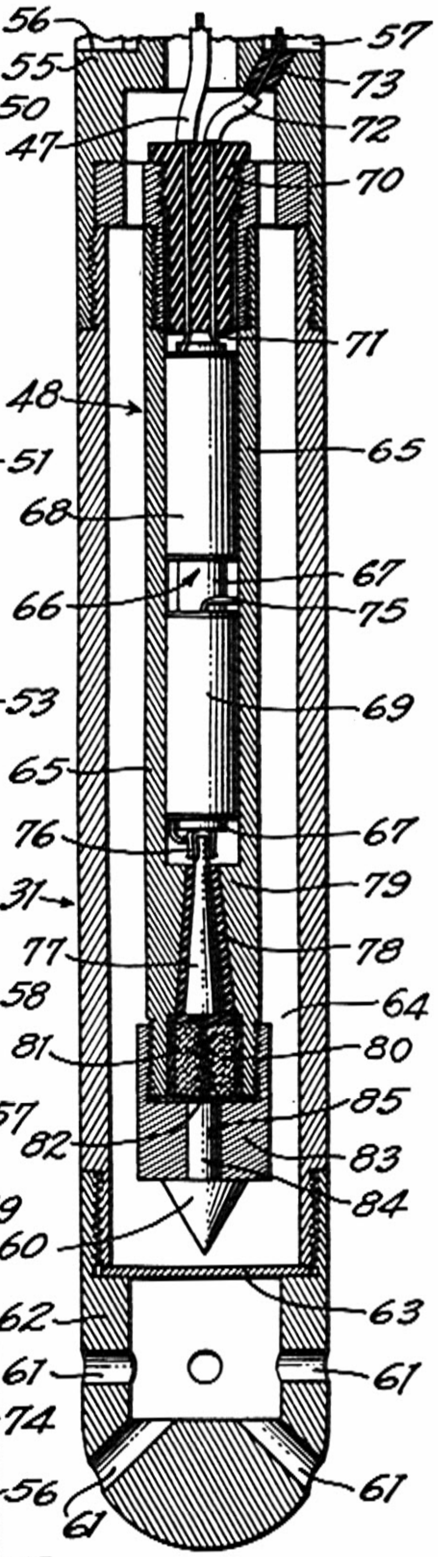
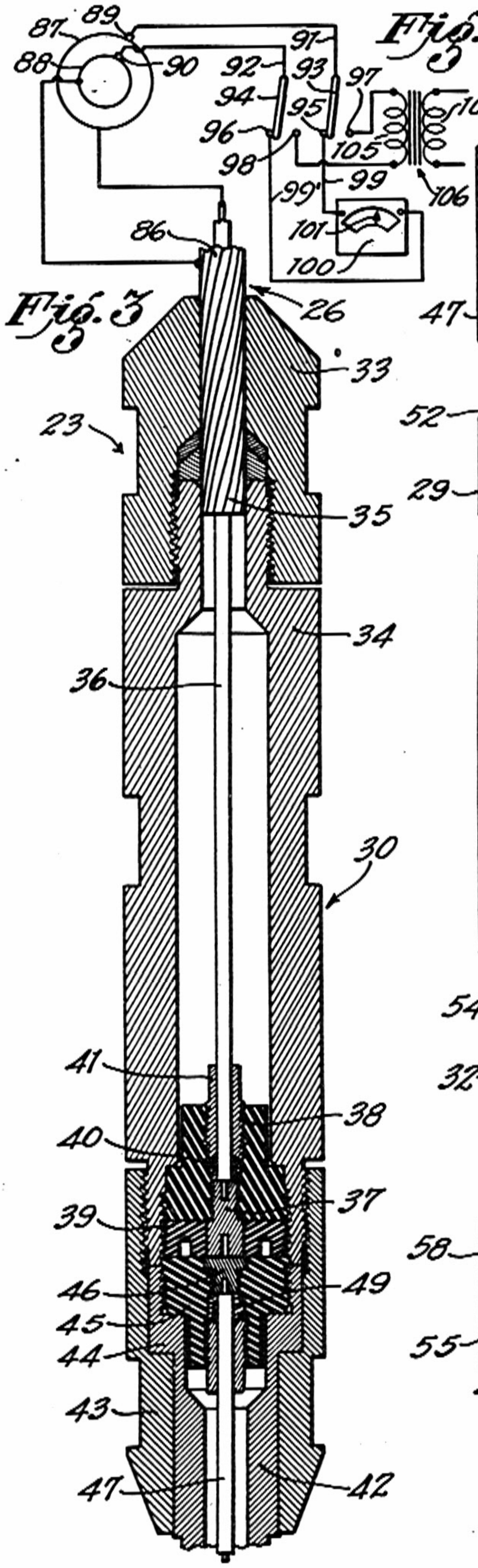


Fig. 3



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METHOD AND APPARATUS FOR DETERMINING WATER LEAKAGES INTO WELLS

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Fig. 6

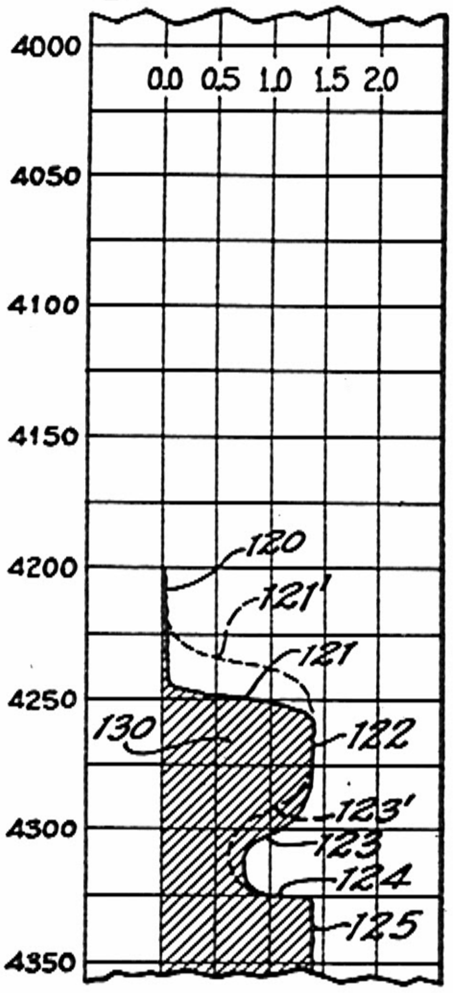


Fig. 7

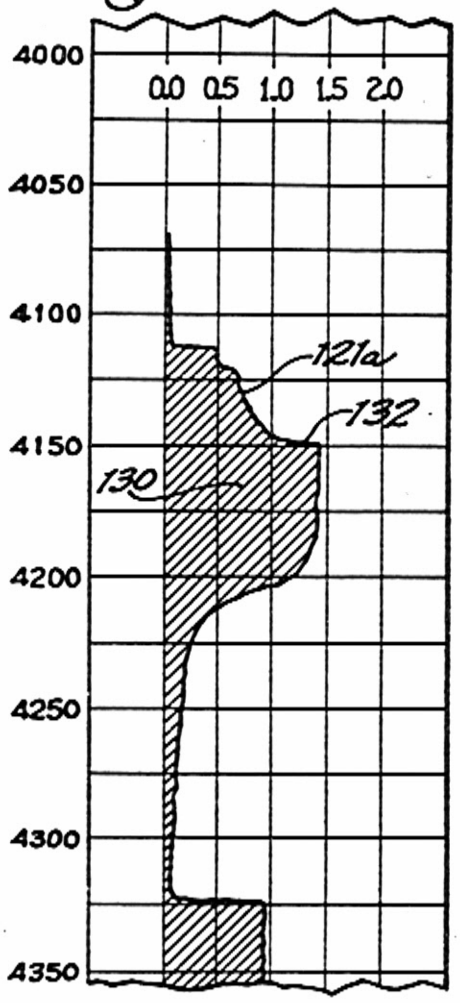
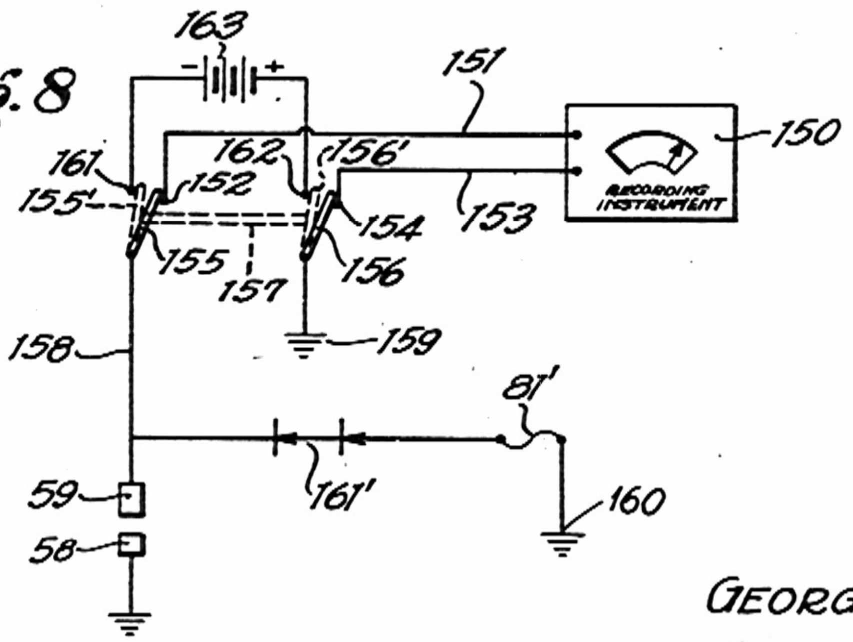


Fig. 8



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METHOD AND APPARATUS FOR DETERMINING WATER LEAKAGES INTO WELLS

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Fig. 9

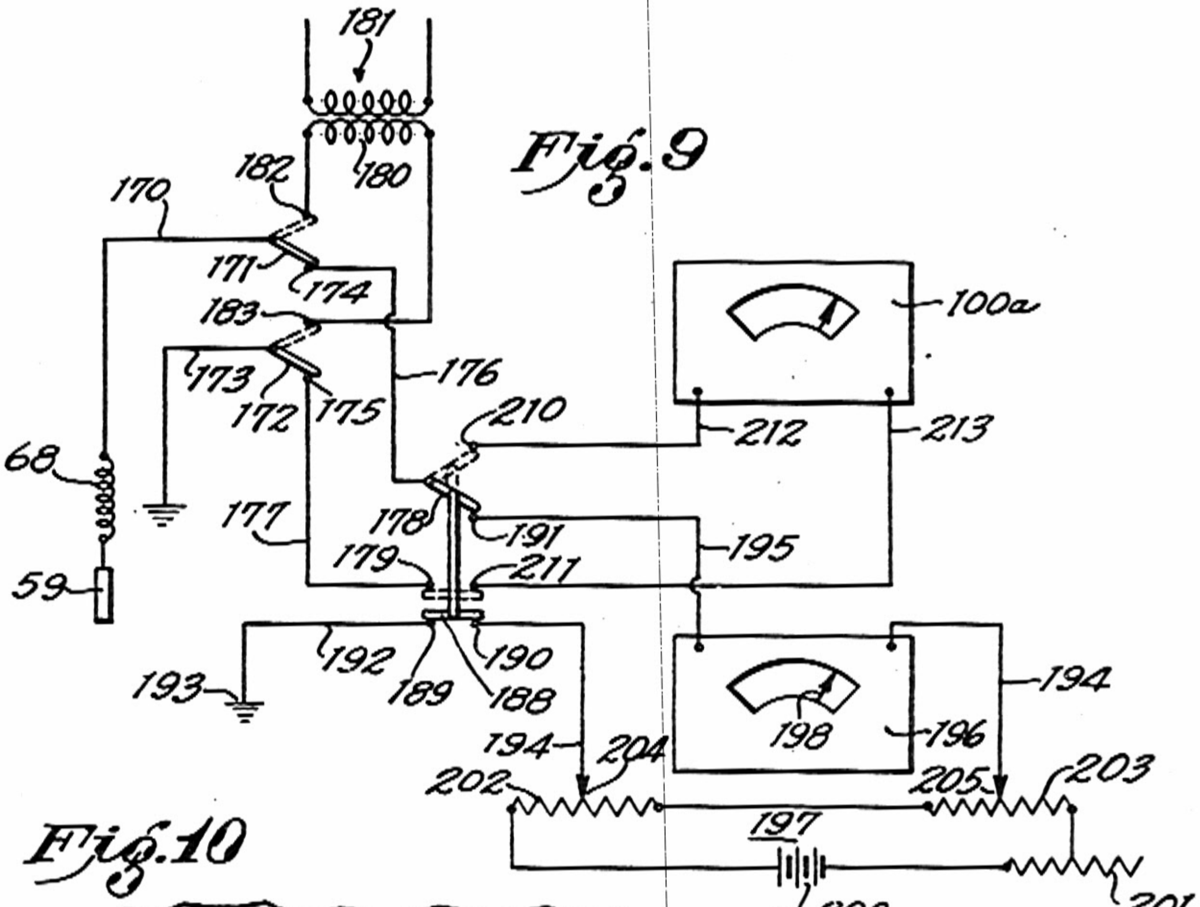
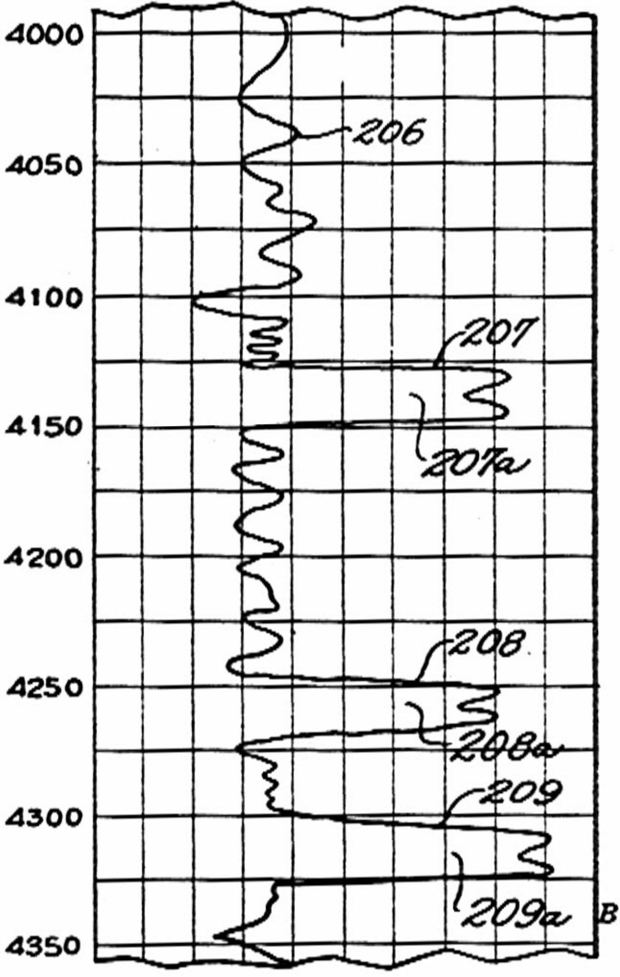


Fig. 10



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UNITED STATES PATENT OFFICE

2,317,039

METHOD AND APPARATUS FOR DETERMINING WATER LEAKAGES INTO WELLS

George H. Ennis, Long Beach, Calif., assignor of one-half to Robert V. Funk, Long Beach, Calif.

Application September 25, 1939, Serial No. 296,449

12 Claims. (Cl. 175—182)

My invention relates to a method and apparatus for testing a well for entry and movement of fluids therein, and relates in particular to a method and apparatus especially adapted for, but not limited to, the testing of wells referred to as flowing wells in contradistinction to pumping wells.

It is an object of the invention to make possible the ready and reliable testing of wells of this type without necessity of first "killing" the well, as has been the general previous practice in the testing of flowing wells to determine points of entry of fluid thereinto. Accordingly, the invention makes possible the testing of a well without the necessity of pumping a weighted material such as drilling mud or a mixture of mud with a heavy weighting material into the well to stop the flow from the formation and to then fill that portion of the hole which is to be tested with a mud conditioned for the purpose of making a test. The old method of testing wells of this type has required from four to eight days to prepare for and complete the testing operations whereas my present invention makes it possible to test a well of the same character in from two to eight hours time.

It is an object of the present invention to provide a method and apparatus whereby a test may be conducted in a well while there is movement of fluid therein. Accordingly, the practice of the present invention does not require the prohibition of entry of fluids into the well during the time the well is being conditioned for the test nor during the actual performance of the testing steps. A feature of this invention is that it likewise makes possible the determination of volumes of fluid entry at different points by reference to rate of travel of the fluid from one point to another in the well, and makes possible the determination of the direction and rate of flow of fluids in a well for example the flow of water in from one formation to and out into another formation may be readily determined in a flowing well. We have found a number of instances where water has entered the well from a high pressure stratum passed from the well into a lower pressure stratum.

It is a further object of the invention to provide a method of testing within a well wherein a conditioning substance is first deposited or distributed in a selected zone in the well and a test is thereafter immediately conducted without the necessity of first withdrawing from the well the delivery device or distributor employed in placing the conditioning material in the well. Accordingly, it is a further object of the invention to provide a well testing device comprising a delivery means for distributing a conditioning material in the well and a testing device for determining variations in the characteristics of the fluid in the well, which testing device may be moved from one position to another in the well without necessity of removing the delivery device from the well.

A further object of the invention is to provide a method especially adapted for use in flowing wells wherein the probable or expected point of entry of water is first determined by a simple preliminary test. A means for obtaining this preliminary observation includes an electrical test of the formation penetrated by the well to determine positions of water sand from which an entry of water into the well might be reasonably expected, this original observation serving as a guide for the placement of the conditioning material, and therefore greatly expedites the making of the complete well test.

A further object of the invention is to provide an improved method of determining zones of water entry into a well wherein a test of the fluid content of the well is correlated with information obtained from a formation test, the information obtained from the curves of these two types of tests serving not only to show the approximate position of the zones from which the water is entering, but also to accurately define the upper and lower limits of this zone.

A further object of the invention is to provide a device having a well conditioning member and a testing element connected so that they may be moved simultaneously within the well and having means extending to the top of the well whereby their movement in the well may be controlled or produced.

It is a further object of the invention to provide a combined delivery and testing device having a hollow body forming a chamber for a conditioning substance and a testing element connecting to the body so as to be moved therewith in the well by means of a suspending cable, the cable carrying or providing conductors for electrical connection with the test element and for electrical connection with a means associated with the chamber whereby the emission of the conditioning material from the chamber may be accomplished.

A further object is to provide a combined delivery and testing device comprising a chamber for a substance to be delivered into the well, this chamber having an electrically controlled means for effectuating the delivery of the substance into the well, and a testing element connected to the device so as to move therewith from one point to another of the well, this testing element having connection with recording or indicating instruments disposed at the top of the well whereby an observer may have knowledge of the operation of the testing element. In the preferred practice of the invention the testing element is of the electro-chemical type where the well is to be tested for entry of water. It will be perceived, however, that this testing element may consist of any one of a number of testing means which have been proposed for the making of tests of fluid in the well, for example, resistance, capacitance, viscometric, and thermometric. A form of testing element especially adapted for use in the practice of the present invention is that of the photo-electric type whereby the opacity or light transmitting qualities of the fluid in the well are measured and compared. Where this type of testing element is employed, the conditioning material delivered by the device could be a dye or other substance effecting the light transmitting or reflecting qualities of water in the well, and under another condition of use the conditioning substance might be a transparent or translucent fluid such as water or oil. It will be understood that a transparent or translucent fluid would be employed as a conditioner where it is desired to determine the point of entry of oil into a column ordinarily substantially filled with oil, an emulsion, or mud. In this instance the translucent or transparent fluid would be applied so as to displace a portion of the contents of a well and photoelectric tests would be immediately conducted along the extent of the deposited fluid to note or seek changes therein indicating the entry of a dark substance from the formation.

It is a further object of the invention to provide a device of the above character wherein the means for effectuating delivery of the conditioning substance from the chamber thereof is accomplished by the use of an ignitable substance which may be an explosive.

A further object is to provide a device for delivery of a substance to a submerged point in a well having a means for effectuating a delivery of the substance from a chamber, which means is controlled or actuated by ignition of a material.

A further object of the invention is to provide a device for delivery of a substance at a submerged point within a well having means for effectuating release of the substance, which means is actuated or controlled as the result of ignition of a material through application of an electrical current controlled by an operator positioned outside the well, for example, at the upper end thereof.

A further object is to provide a device to be lowered into a well, comprising a body having a chamber connecting with the exterior through an opening, a wall closing this opening, and explosive means for rupturing this wall so that a flow through the opening may occur.

Further objects and advantages of my invention will be brought out in the following part of the specification.

Referring to the drawings which are for illustrative purposes only:

Fig. 1 is a view showing the upper end of a well equipped for the making of a test.

Fig. 2 is a cross-section showing a lower portion of the well with the testing device suspended therein.

Fig. 3 is an enlarged cross-sectional view of the cable head forming a part of the combined delivery and testing device.

Fig. 4 is an enlarged cross-section of the upper portion and testing element of the combined delivery and testing device.

Fig. 5 is an enlarged sectional view of the lower portion of the combined delivery and testing device.

Fig. 6 is a graph of a test taken in a zone in the well immediately after the distribution of the conditioning substance therein.

Fig. 7 is a graph of a test made in the same zone a short time later.

Fig. 8 is a diagram showing a means whereby direct current may be employed for ignition of the explosive for releasing the conditioning substance.

Fig. 9 is a diagram showing an arrangement of elements which I may employ in the making of correlated tests of the fluid content and the formation of a well.

Fig. 10 is a curve representing changes in formation of the well shown in Fig. 2.

In Figs. 1 and 2 I show a casing 10, having a shoe 11 at the lower end thereof. This casing 10 may be suspended within a larger casing 12 by means of a casing head 13 which also supports an oil tube 14 which projects down within the casing 10 to a point near the lower end thereof and has a throat 15 at or near its lower end. The upper end of the oil tube is connected to a christmas tree 16 including oil delivery pipes 17 provided with valves 18. Projecting upwardly from a valve 19 in alignment with the tube 14 a lock 20 is mounted, this lock being sometimes referred to as a lubricator and consisting of a length of pipe 21 with a control head 22 at the upper end thereof. This pipe 21 being of such length that the combined delivery and testing device 23, shown in Fig. 2, may be lowered thereinto through the control head 22 when the valve 19 is closed off against the well pressure. This control head has a rubber wall 24 surrounded by a fluid chamber 25. When fluid is pumped into the chamber 25 through a pipe 27, the rubber wall will be forced radially inward so as to be constricted around the cable 26 which extends therethrough for the purpose of supporting and lowering or raising the device 23. After the rubber member 24 has been constricted so as to seal around the cable, the gate 19 may be opened so that the device 23 may be lowered through the tubing 14 into the lower portion 28 of the well lying below the shoe 11 of the casing 10.

As shown in Fig. 2, the device 23 is of small diameter so that it will pass through the throat 15. Ordinarily this device 23 has an external diameter of one and three-quarter inches and a length of about 37 to 40 feet. It comprises a relatively long upper section 29 which is connected to the cable 26 by means of a cable head 30, and a lower section 31 spaced from the upper section 29 by a testing element 32. As shown in Fig. 3, the cable 26 is led into a cable socket 33 which is threaded on the upper end of a sleeve 34. From the end 35 of the cable which is locked in the socket 33, an insulated conductor 36 is extended down to a contact 37 which threads into an insulator bushing 38 which is held in the lower end of the sleeve 34 by means of a threaded ring 39 of insulating material. Above the contact 37 the insulator bushing 38 is provided with a gland 40 compressed around the insulation of the conductor 36 by means of a gland nut 41. The cable head is detachably connected to the upper end of the upper section 29 by means of a union comprising a hollow member 42 which threads into the upper end of the member 29 and a shouldered sleeve 43 which forces a head 44 on the upper end of the member 42 against the lower end of the member 34 of the cable head 30. The head 44 carries an insulator 45 which holds a contact 46 in position for engagement with the contact 37 when the parts are secured together, as shown in Fig. 3. From this contact 46 an insulated conductor 47 extends, as shown in Figs. 4 and 5, down through the hollow member 42 and thence down through the upper section 29 and the testing element 32 to an electro-responsive device 48 situated in the lower section 31. Below the contact 46, the insulator 45 is provided with a gland 49 for sealing around the upper end of the conductor 47, and a guide 50 for the conductor is threaded into the lower end of the tubular member 42. The upper section 29 has a chamber 51 with a small opening 52 leading into its upper end. At the lower end of the section 29 there is a bushing 53 into which the upper end of a tubular wall 54 is screwed. This tubular member 54 has a cylindrical enlargement 55 which threads on to the upper end of the lower section 31, as shown in Fig. 5, and provides a shoulder 56 for forcing the testing element 32, which surrounds the tube 54, against the lower end of the bushing 53.

The testing element 32 comprises a spool 57 of insulating material, the ends of this spool each supporting a half of a divided metal electrode 58 thereon, and the throat of the spool 57 having a cylindrical sleeve 59 forming a second electrode. These electrodes are of such metals as to cooperate in forming a galvanic cell when immersed in an electrolyte. In the general use of the invention I find that satisfactory results may be obtained by the use of zinc for the electrode 58 and an alloy of gold and silver for the element 59.

The electro-responsive device in the lower section 31, Fig. 5, controls the actuation of a member 60 adapted to effectuate the passage of fluid through openings 61 in a cap 62 which is secured to and forms a part of the lower section 31. In the preferred practice of the invention a disc 63 is placed between the cap 62 and the lower end of the member 31 so as to provide a diaphragm or obstructing wall and the member 60 preferably constitutes a projectile which may be caused to rupture, shatter, or penetrate the wall 63 so that there will be a direct communication between the space 64 and the openings 61.

The electro-responsive device 48 is somewhat diagrammatically shown as comprising a tubular shell 65 in which a transformer 66 is supported. This transformer has a core 67 on which primary and secondary windings 68 and 69 are formed. The conductor 47 which passes down through the tubular member 54 is carried through a suitable sealing means 70 disposed at the upper end of the tubular shell 65 and is connected to one end of the primary winding 68. The remaining end 71 of the primary winding 68 is brought out through the sealing means 70 and by means of a conductor 72 is connected with the sleeve electrode 59. The conductor 72 is carried through a small insulator 73 mounted in the wall of the enlargement 55 and passes from this insulator 73 through an opening 74 in the lower head of the spool 57. One end of the winding 69 is connected by means of a ground 75 with the tubular shell 65 of the electro-responsive device 48. The remaining end of the winding 69 is connected to a spring contact 76 mounted on the lower end of the transformer core 67, for engagement with the upper end of an insertable taper pin 77 which is passed upward through a tapering opening in a tapered insulator bushing 78 supported by means of a wall 79 near the lower end of the shell 65. Below the bushing 78 there is a powder chamber 80 to receive a charge of powder through which an igniting element 81 comprising a fine strand of resistance wire is extended to a thin metal plate 82 held in place against the lower end of the shell 65 so as to be grounded against the lower end of the shell 65. A cap 83 is threaded on to the lower end of a shell 65 for the purpose of holding the metal wall 82 in place and for the further purpose of supporting the projectile 60 which has a stem 84 projecting upward into an opening 85 in the cap 83. Both of the zinc electrodes 58 are grounded with the metal shell of the device 23 so as to have electrical connection with the sheath 86 of the cable 26.

As shown in Fig. 3 the conductor 36 may be connected to a commutation ring 87 and the cable sheath 86 may be connected to a commutator ring 88, both of these rings being mounted on the cable drum on which the cable is wound. Brushes 89 and 90 engage the rings 87 and 88 and are connected through conductors 91 and 92 with switch members 93 and 94 adapted to be swung from responsive engagement with contacts 95 and 96 to engagement with contacts 97 and 98. The contacts 95 and 96 are connected through wires 99 and 99′ with an electro-responsive indicating device 100 constituting a millivolt meter. The contacts 97 and 98 are connected to the secondary 105 of an A. C. transformer 106 having a primary winding 107.

When the device 23 is lowered into an electrolyte, the electrodes 58 and 59 form a galvanic cell generating a potential which may be measured by the indicating device of meter 100 together with such changes as may be caused by polarization of the cathode 59. In the general practice of the invention the aqueous solution is produced in the well by distributing throughout a select portion of water in the well a suitable conditioning material. This conditioning material in the preferred practice of the invention is a solution of sodium bichromate and sulphurc acid. When the water in the well is first conditioned a voltage will be generated by the testing element 32 near to the maximum voltage characteristic of the electro-chemical qualities of the electrodes 58 and 59 in the prescribed aqueous solution in the well. As the solution is diluted there will be a slow drop-off in the potential produced by the testing element 32, and when the dilution approaches 90% there will be a rapid drop in the potential generated between the electrodes 58 and 59.

In one use of the device the following method may be employed: The upper and lower chambers 51 and 64 of the device 23 are filled through the opening 52 after the assembly of the parts previously described, that is to say, with the disc 63 in place and with the bullet 60 and explosive installed in operative position thereabove. If the pressure under which the well is operating is not great, the device 23 may be lowered into the lock 20 and after actuation of the control head 22 the gate 19 may be opened and the device 23 lowered through the christmas tree and the tubing 14 into the lower part of the well to a position such as shown in Fig. 2. For the purpose of illustration, a lower water sand 108 and an upper water sand 109 are shown, both of which are feeding water into the bottom part of the well so that the well is filled with water 110 below the oil producing stratum 111. The device 23 is lowered to the bottom of the well or to a point near the bottom of the well, the distance of travel thereof being determined by means of a measuring sheave 112 under which the cable is passed, as shown in Fig. 1, to an upper supporting sheave 113 disposed above the christmas tree 16. While there is a movement or flow of fluid in the well, a portion of the water near the bottom of the well is conditioned by distributing the contents of the chambers 51 and 64 therein. To accomplish this the preferred practice is to lower the device 23 to the lower end of the zone in which the distribution of conditioning fluid is to be made, in this instance to the bottom of the well. The switch members 93 and 94 are then swung from their positions in Fig. 3 into engagement with the contacts 97 and 98 whereupon an alternating current may be fed through the primary winding 68 of the transformer 66. This will induce an alternating current in the secondary winding 69 which is connected in circuit with the filament 81 which due to the passage of the current therethrough becomes immediately heated and ignites the powder charge in the chamber 80 with the result that the bullet 60 is propelled downward so as to rupture the disc 63 thereby permitting the conditioning fluid to flow out through the openings 61 into the water in the well as the device 23 is raised at a suitable rate, for example, approximately 100 to 150 feet per minute as selected by the operator in accordance with his understanding of the diameter of the hole having therein the water to be conditioned.

After the discharge of the projectile 60, the device 23 is pulled upward as previously described. Knowing the approximate rate of discharge of the conditioning solution from the device, the operator will stop the device in a position spaced above the level at which he expects that the chambers of the device 23 will have been emptied. For example, the device 23 may be of such capacity, as to hold sufficient conditioning fluid for approximately 75 to 100 feet of well water. The operator may raise the device to a point 150 feet from the bottom of the well which, as indicated in chart, Fig. 6, is at a distance of 4350 feet from the surface. He will then immediately swing the switch members 93 and 94 back into engagement with the contacts 95 and 96 and will lower the device 23 gradually. Assuming that he has started down from the 4200 foot level, indicated in Fig. 6, he will first obtain a reading 120 of zero or near zero voltage depending upon whether the water in the well above the conditioned portion of the well is substantially pure or has a salt content. As the testing element 32 enters the conditioned fluid in its downward travel the potential registered by the meter will immediately rise to a point near maximum. For example, there will be an abrupt rise at 121 to approximately 1.4 volts, and as the device is continued downward, the reading as indicated at 122 will remain near maximum until a point of dilution is indicated by a drop-off 123 in the reading. This drop-off 123 will indicate the entry of water into the conditioned contents of the well. When the testing element 32 reaches and passes the point of entry of the water, there will be a rise 124 to a point near maximum, and if there is no lower point of water entry into the well the section 125 of the reading will remain at the point near maximum all the way to bottom. The reading thus taken indicates that the lower point of the water entry is at the 4325 foot level.

The upper point of this water entry is, of course, not known at the time of making the initial test for the reason that there has been a continuous upward movement of water from the point of entry from the time of depositing the conditioning solution to the time of return of the device 23 from the 4200 foot level to the zone of water entry which has its lower plane at the 4325 ft. level. The upper level of the zone of the water inlet 108 may be readily approximated however by checking the rate of rise of the drop-off 123 and then computing the initial position of the drop-off 123 at a time just following the distribution of the conditioning material in the portion of the well between the 4300 and 4325 foot levels. With relation to the foregoing it will be understood that as the water continues to flow into the well from the source 108, the body of conditioned fluid above the 4325 foot level, indicated by the cross-sectioned area 130 of Fig. 6, will be gradually displaced upward as indicated by dotted lines 123' and 121'. The upward movement of this body of conditioned water may be traced by consecutive readings obtained by use of the testing element 32 and the associated meter 100, and should this upwardly moving body of conditioned water encounter a further entry of formation water, for example, from the sand 109, the curve obtained will indicate the same. By reference to Fig. 6 it will be noted that the rise 121 in the curve is relatively abrupt, indicating that when the testing element 32 is lowered from the fresh water in the upper part of the well into the conditioned fluid, it has encountered a rapid change or increase in the strength of the solution. When the upward moving body of conditioned solution 130 reaches the plane at which water is entering from the sand 109 there will be a dilution of the solution causing the rise 121 to have a stepped form as shown at 121a in Fig. 7, the shoulder 132 indicating the approximate position of the lower plane of the entry of water from the sand 109 as being approximately at the level of 4148 feet below the surface.

To check on this latter indication of the entry of water at about the 4148 foot level, a new test may be made or the first test hereinabove described may be supplemented, in the following manner. The device 23 is pulled from the well and recharged with conditioning solution. It is then lowered to the 4200 foot level, and while being moved upward to the 4100 foot level will be caused to discharge the conditioning fluid. The device 23 will then be immediately lowered so that the testing element 32 will traverse the distance between 4100 feet and 4200 feet to obtain a reading from the meter 100 which will be similar to that shown in Fig. 6 but which will have a drop-off and rise occasioned by the dilution of the conditioned well water caused by entry of formation water from the sand 109.

It will be understood that the foregoing determinations have been made while well fluids have been moving upward in the well from their point of entry and without the necessity of cutting off of all production from the top of the well, nor the loss of time which would be occasioned in attempting to bring the well to a static condition by completely closing the upper end thereof. Such closing of the upper end of the well would ordinarily be inadvisable for the reason that in a flowing well the fluids enter from formations under different pressures, and unless a somewhat normal flow is permitted, the backing up of these pressures will result in the higher pressure from one formation causing a reverse flow of fluid into another formation. Likewise, the accumulation of gas in the upper part of the well will at times cause a pressure build up which will result in reverse flows into low pressure formations. From the foregoing it will be perceived that tests made after killing the production of a well could not be depended upon as being entirely reliable; whereas, tests made in the well while there is an upward flow of fluid therein in accordance with my present invention, are entirely reliable.

There are many variations of the practice of the method, as will be hereinafter indicated, to adapt the same to the various conditions which may be encountered. For example, if the well in which the test is to be made is flowing under very high pressure, it may be necessary to pump a weighted material, such as mud, into the upper part of the oil tube to offset a portion of the pressure which is acting upward through the oil tube against the seal formed by the control head 22. Under such circumstances the well may be permitted to produce through the upper end of a casing 10, a pipe 135 and valve 136 being shown connected to the casing head 13 for this purpose. In many instances it is found desirable to materially reduce the flow from the well by closing down on the outlet valve so that the upward movement of fluids in the well may be reduced to a reasonable extent. In some instances, I may take advantage of the fact that even after the valves at the top of the well are completely closed there continues to be a flow of fluids into the well from the formation, since the upper part of the casing 10 is ordinarily occupied by gas, which is compressible so that there may be an upward movement of liquid in the well until such time as the gas pressure in the well balances the pressure of entering fluid. In many wells a dormant condition of the fluid therein is not reached until after the valves have been closed down for a period of six to eight hours, and even at such time there may continue to be a flow of fluid from a high pressure formation into a lower pressure formation. Accordingly, I prefer to test a well of the flowing type without entirely shutting off the flow from the upper end thereof, or during a short period of time immediately after the valves are closed, for the reason that during this short period of time after the closing of the valves, there is still an upward movement of fluid from the formation into the well.

In Fig. 8 I show an arrangement wherein the means for effectuating the delivery of the conditioning material into the well is accomplished through use of a direct current. Herein a recording or indicating instrument 150 is connected through a conductor 151 with a switch contact 152. Another conductor 153 is carried to a switch contact 154. A throw-over switch is provided having switch members 155 and 156 which are linked together as indicated at 157 so that when switch member 155 is in engagement with the contact 152, switch member 156 will be in engagement with contact 154. A conductor 158 is carried down through the cable 26 to the gold electrode 59 in the combined delivery and testing device 23, the zinc electrode 58 being grounded with the cable. The switch member 156 is connected through a ground 159 with the cable 26. When the switch members 155 and 156 are in the positions in which they are shown in full lines in Fig. 7, the immersion of the electrodes 58 and 59 in an electrolyte will produce a potential which will be recorded or indicated by the instrument 150.

The actuating means for effecting the opening of the passages which connects the interior of the device 23 with the exterior is shown as a filament or fuse 81′, one side of which is grounded as indicated at 160, and the other side of which is connected through rectifiers 161′ with the conductor 158. Contacts 161 and 162 are disposed so as to be engaged by the switch members 155 and 156 when such switch members are moved into the positions indicated by dotted lines 155′ and 156′. A battery or other source of direct current 163 is connected to the contacts 161 and 162 so that positive current will be fed through the switch member 156 and the ground connection 159 and 160, through the filament or fuse 81′, the rectifiers 161′, the conductor 158, and the switch member 156 to the negative pole of the battery 163, thereby electrifying the member 81′ to effectuate discharge of the conditioning material. Immediately thereafter the switch members 155 and 156 may be returned to their engagement with the contacts 152 and 154 so that as soon as the conditioning material is distributed in the well the electrodes 58 and 59 and the instrument 150 may be employed to test the conditioned fluid in the well.

In one practice of the invention I employ a preliminary test to determine the probable point of entry of water into the well and in some instances may employ a pressure recording device by which to indicate the level at which water is standing in the well. If the well being tested is in a field wherein other wells have been cored by the electrical method, the first test of my present invention is to make the formation test to determine the position of sand and shale, the information thereby obtained serving as a guide in making the remainder of the water entry test in a manner such as heretofore described. In Fig. 9 I diagrammatically show the apparatus by which this extended practice of my method may be performed.

Therein a conductor 170 is connected to the gold alloy electrode 59 of the device 23 and to a movable switch member 171. A switch member 172 is connected to a conductor 173 with the cable sheath 86. When the switch members 171 and 172 are in engagement with contacts 174 and 175, they will be respectively connected to conductors 176 and 177 with a switch member 178 and a contact 179. When the switch members 171 and 172 are in the alternate positions thereof indicated by dotted lines they will be connected with the secondary 180 of a transformer 181 by reason of their engagement with contacts 182 and 183, this latter position of the switch members 171 and 172 being employed when it is desired to transmit an alternating current to the device 23 in the well to effectuate delivery of the conditioning material.

The movable switch member 178 is linked to a switch member 188 which is adapted to engage contacts 189 and 190 when the switch member 178 is in engagement with a contact 191, as shown in full lines in Fig. 9. From the contact 189 a conductor 192 is carried to a ground 193 which may be connected to the well casing or directly to the soil. The contacts 190 and 191 are connected by conductors 194 and 195 with a microvoltmeter 196, the conductor 194 having a potentiometer balancing device 197 in series therewith to balance the potential effective in the circuit to the meter to such extent that the needle 198 thereof may be brought to a centralized position. The balancing device 197 consists of a battery 200 connected to a variable resistor 201 with series resistance element 202 and 203 engaged respectively by movable brushes 204 and 205 which have series connections with the conductor 194.

With the switch members 171, 172, 178 and 188 in the positions in which they are shown in full lines in Fig. 9, the device 23 is lowered into the well. As the device 23 passes through the successive strata, electro-potential variations will be impressed on the circuit which connects the electrode 59 with the ground member 193. In the operation of the device there will be a flow of current from the electrode 59 through conductor 170, switch member 171, conductor 176, switch member 178, conductor 195, meter 196, conductor 194, switch member 188 and conductor 192 to the ground member 193. In Fig. 10 I show a graph of the readings obtained while the device 23 is moved downward in the well shown in Fig. 2 from the 4000 foot level to the 4350 foot level. It will be understood that in the curve 206, thus plotted no attempt has been made to show the minor fluctuations of the needle 198. In accordance with the general principles of electrical well coring, set forth in my copending application, Serial No. 28,891, the rightward excursions 207, 208, and 209 may indicate sands, and since entry of water into a well is ordinarily from sand formation, the operator will seek entry of water from these sands. Accordingly, he will distribute conditioning material in zones in the well extending from points below to points above the sands and will conduct his tests in accordance with the general method previously described herein.

After release of the conditioning material from the device 23, which is accomplished by throwing the switch members 171 and 172 into engagement with the contacts 182 and 183 so as to supply the winding 68 of the transformer 66 with alternating current from the transformer 181, the switch members 178 and 188 are raised into the positions thereof indicated in dotted lines in Fig. 9 so that the switch member 178 will engage a contact 210 and the switch member 188 will engage the contact 179 and a contact 211, these contacts 210 and 211 being respectively connected through conductors 212 and 213 with a millivoltmeter 100a having the function of the voltmeter 100 shown in Fig. 3. Accordingly, tests of the concentration of the liquid in the well may be made with the device 23 as previously described.

An important feature of my method and apparatus concerns the ability to correlate a test of the fluid content of the well with a test of the formation of the well so that information obtained by the test of the fluid in the well may be verified or corrected by the information obtained from the test of the formation by the electrical coring method. According to the invention, the extended form of my device shown in Fig. 9 is employed to make tests of the fluid content of the well from which the information disclosed in the charts 6 and 7 is obtained and also a test of the formation to obtain the chart shown in Fig. 10. The sequence of these tests is not important, although in the general practice of the invention the formation test is first made, then the conditioning material is distributed and the tests of the fluid content are made. The curve 206 indicates sand in the positions 207a, 208a, and 209a of the rightward excursions 207, 208, and 209, but the charts 6 and 7 show that there is an entry of water only from the sands 207a and 209a, but not from the formation 208a. The chart, Fig. 10, shows the lower plane of the formation 209a at the 4325 foot level, which agrees with chart 5 wherein the rise 124 indicates entry of water at the point 4325 level. The upper plane of the formation 209a is shown to be at the 4305 level which indicates accordingly that the height of the water source represented by the formation 209a is 20 feet. Likewise the excursion 207 of the curve 206 checks the position of the point 132 of water entry in Fig. 7 as being at a level of substantially 4148 feet, and the excursion 207 shows the upper plane of the formation or in other words the upper point of water entry from the formation 207a as being substantially in the 4127 foot level below the surface of the ground. The foregoing method makes it possible in the testing of flowing wells, and especially those flowing wells in which the velocities of fluid are relatively high, to obtain accurate and reliable information concerning the entry of fluid into the well.

I claim as my invention:

1. A method of testing a well, in which there is a flow of fluid, for entry of water thereinto, comprising: making a test to determine the location of a body of water in the well; introducing a conditioning solution into said body of water; and immediately thereafter testing consecutive portions of said body of water.

2. In a device of the character described, whereby fluid in a well may be conditioned and immediately thereafter tested, the combination of: a hollow body providing a chamber for a conditioning material which is to be distributed in fluid in the well; means for causing discharge of said conditioning material from said chamber into the fluid in a selected portion of the well; testing means connected to said body so as to move therewith in the well, said testing means being operative to produce sensible indication of the changes in condition in the fluid in said portion of the well; and means for moving said body and said testing means in the well.

3. In a device of the character described, whereby the fluid in a well may be conditioned and immediately thereafter tested, the combination of: a hollow body forming a chamber to hold a conditioning material, said chamber having discharge valve means, means for actuating said valve means so that said conditioning material is discharged into a selected zone of the well; testing means connected to said body so as to move therewith in the well, said testing means being operative to produce sensible indication of the changes in condition in the fluid in said zone; and means operative to move said body and said testing means in the well.

4. In a device of the character described, whereby the fluid in a well may be conditioned and immediately thereafter tested, the combination of: electrically controlled fluid distributing means operative in a well to distribute a conditioning material in fluid in the well, there being

conductors extending to the top of the well whereby delivery of fluid from said distributing means may be controlled; electrical testing means movable in the well during the time said fluid distributing means is in the well, operable to test the conditioned fluid in the well without necessity of removing said fluid distributing means from the well; and means comprising said conductors for transmitting from said testing means to the top of the well indications of the tests which may be noted by an observer.

5. In a device of the character described, to be lowered into a well, the combination of: a hollow body forming a chamber having an opening from the interior to the exterior; means for moving said body in the well; electrically controlled means for effectuating movement of fluid through said opening when said hollow body is in a desired position in the well; an electrical testing means movable in said well while said body is in the well; means forming an electrical circuit extending from said testing means to the top of the well; and a conductor to connect said circuit to said electrically controlled means whereby electrification may be transmitted to said electrically control means to actuate the same.

6. A method of the character described, for testing a well for entry of water thereinto, wherein a conditioning means and a testing device are employed, said conditioning means carrying a substance to condition the interior of the well, and said testing device having means for making observations of the contents of the well, comprising: lowering said conditioning means and said testing device into the well in such timed relation that they will be both in the well at the same time; delivering from said conditioning means into a selected zone in the well a quantity of said substance; and operating said testing device to make an observation of the contents of the well in said zone.

7. A method of the character described, for testing a well for entry of water thereinto, wherein a conditioning means and a testing device are employed, said conditioning means carrying a substance to condition the interior of the well, and said testing device having means for making observations of the contents of the well and for making an electrical formation test, comprising: lowering said conditioning means and said testing device into the well in such timed relation that they will be both in the well at the same time; making an electrical formation test by use of said testing device; delivering from said conditioning means into a selected zone in the well a quantity of said substance; and operating said testing device to make an observation of the contents of the well in said zone.

8. A method of the character described, for testing a well for entry of water thereinto, wherein a conditioning means and a testing device are employed, said conditioning means carrying a substance to condition the interior of the well, and said testing device having means for making observations of the contents of the well and for making an electrical formation test, comprising: lowering said conditioning means and said testing device into the well in such timed relation that they will be both in the well at the same time; making an electrical formation test by use of said testing device; delivering from said conditioning means into a selected zone in the well a quantity of said substance; operating said testing device to make an observation of the contents of the well in said zone; and correlating the data of both of said tests to define the point of entry of water into said well.

9. A method of the character described, for testing a well for entry of water thereinto, wherein a conditioning means and a testing device are employed, said testing device having means for making observations of the contents of the well, comprising: lowering said conditioning means and said testing device into the well in such timed relation that they will be both in the well at the same time; utilizing said conditioning means to condition a selected zone in the well; and operating said testing device to make an observation of the contents of the well in said zone.

10. In a method of testing a well in which there is a flow of fluid, the steps of: conditioning a selected portion of the well; and thereafter making consecutive observations of the fluid in said selected portion of the well by use of a testing device, whereby data concerning positions of moving and/or stationary portions of said fluid may be established.

11. In a method of testing a well in which there is a flow of fluid, the steps of: conditioning a selected portion of the well; thereafter making consecutive observations of the fluid in said selected portion of the well by use of a testing device, whereby information of the relative movement and relative positions of different portions of the fluid may be determined; and comparing the results of said consecutive observations to fix the position of the point of entry of fluid into said well.

12. In a method of testing a well in which there is a flow of fluid, the steps of: conditioning a selected portion of the well; thereafter making consecutive observations of the fluid in said selected portion of the well by use of a testing device; recording the relative positions and relative rates of flow of different portions of the fluid in said selected portion of said well, as shown by said consecutive observations; and correlating the data of the records thus obtained to determine the point of entry of fluid into the well.

GEORGE H. ENNIS.

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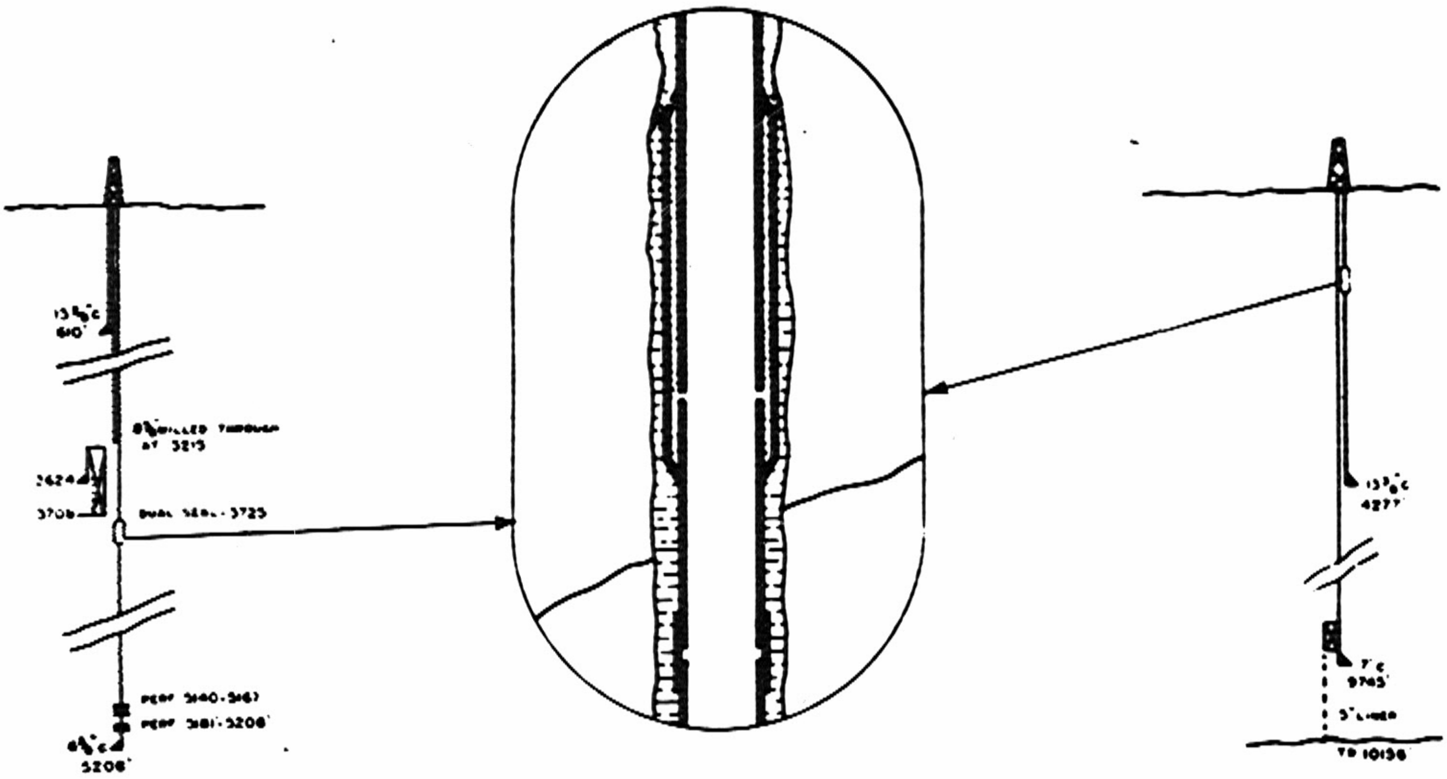
1939 Div 32

DEVELOPMENT OF THE DUAL SEAL CEMENTER



A TYPICAL EXAMPLE

This well had been produced between 3,624 feet and 3,708 feet. After several years, the liner had collapsed, and in attempting to repair it, tools had been lost and the well was plugged and abandoned. Upon the discovery of a deeper zone in the area, the program as shown in the sketch was outlined. A Kinzbach whipstock was set at 3,215 feet in the 8⅝" casing and a window milled through. A 7¾" rotary hole was drilled to 5,208 feet. Occasional cores were taken and Electrolog run. 6⅝" casing with flush joint below 3,193 feet was run and cemented at 5,208 feet, with 150 sacks of cement. A Dual Seal Cementer had been placed in the 6⅝" casing string at 3,725 feet. Upon completion of the lower cement job, the upper stage cementing was done with 175 sacks of cement. After cleaning out and testing, the zones as shown on the Electrolog chart between 5,140 feet and 5,167 feet, and 5,181 feet and 5,204 feet were Gun Perforated. Initial production was F184—26.2—0.4%.

DE SOTO OIL CO.—DE SOTO No. 1

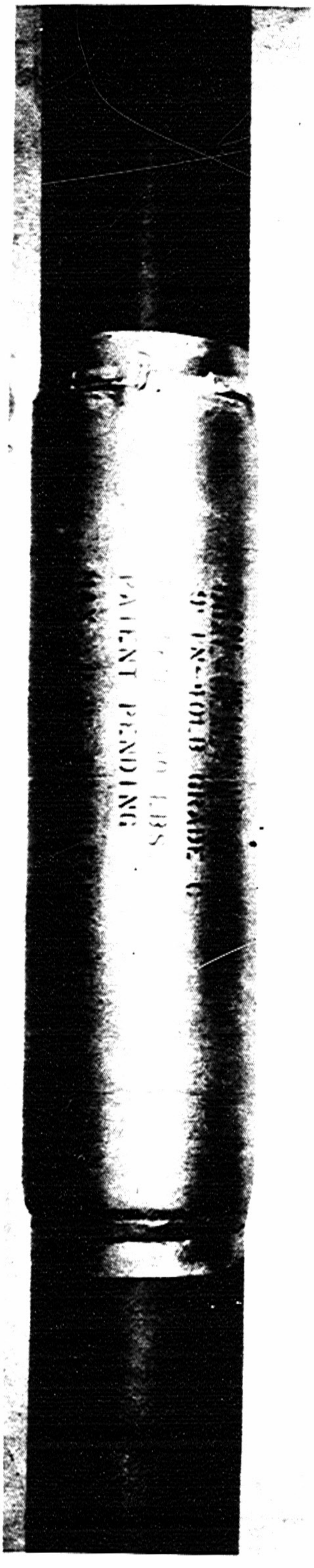
A short 22" conductor was set and 18⅝" hole drilled to 4,277 feet. 13⅜" 61# casing cemented at 4,277 feet using 1650 sacks of cement—1600# pressure, and also cemented through Dual Seal Cementer placed in 13⅜" casing string at 598 feet using 400 sacks of cement at 750# pressure.

The well has now been drilled as shown to 10,156 feet with 7" casing cemented at 9,745 feet and 438 feet of 5" liner, including 396 feet of perforated landed at 10,156 feet. Completed December 13, 1938 on gas lift and present production is 265 B/D—29.7 —0.5% cut.

The De Soto Oil Co., De Soto No. 1, is located in the Lovelady Pool area of Signal Hill (Long Beach). Scheduled as a deep test, the Dual Seal Cementer was selected as a means of sealing surface sands and replacing a string of 18⅝" casing. As shown in the sketch and well data on the right, results were satisfactory. The officials and crews of the De Soto Oil Co., under the direction of R. W. Jerman, President, are to be complimented on obtaining the first production below 10,000 feet in the Los Angeles basin.

Lane Wells Co.

1939

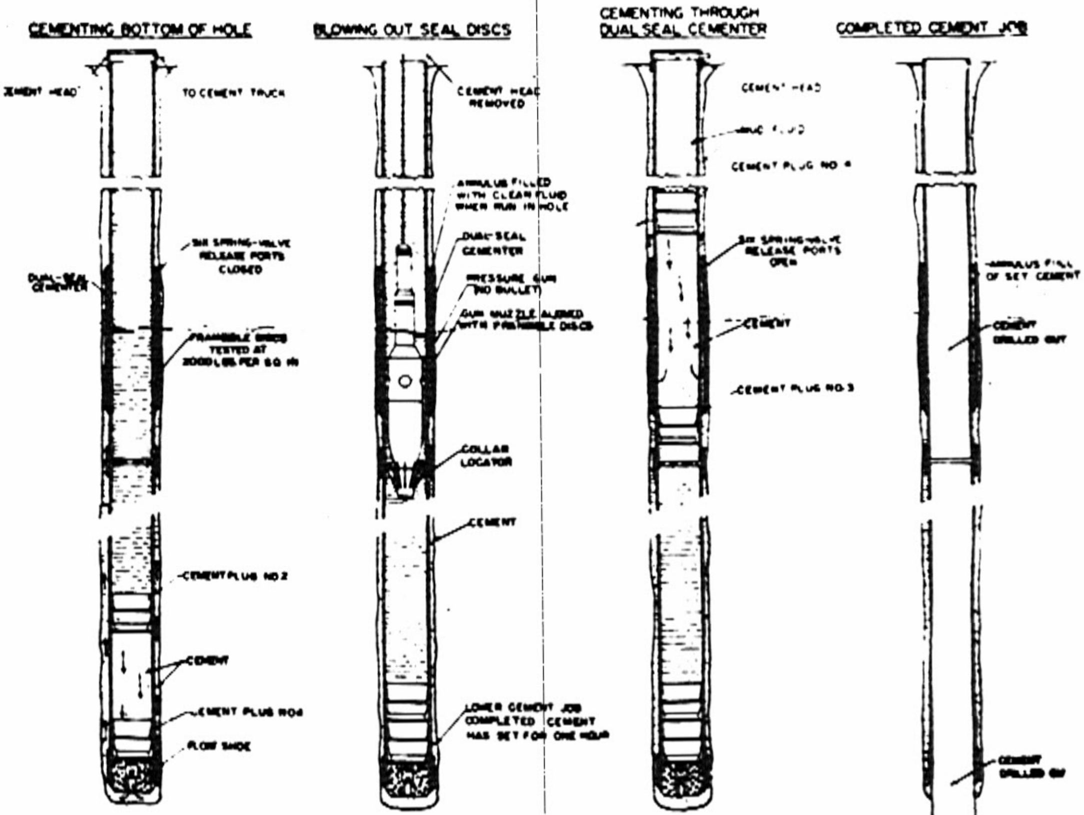


● The Dual Seal Cementer enables the operator to place a large amount of cement behind a single string of casing, for the purpose of protecting upper oil and gas sands or surface fresh water sands. It may also be used to protect against caving formations or the action of corrosive waters. The Dual Seal Cementer was developed to meet the needs of oil companies for fast, efficient and economical upper stage cementing. The time and pressures required for placing this cement are greatly reduced.

OPERATION

The diagrams below show the field usage of the Dual Seal Cementer. The device is placed in the casing string, at the specified depth below the derrick floor. The casing is cemented on bottom as though the Dual Seal Cementer were not in the casing string. The float shoe and float collar prevent back-flow and permit the removal of the cementing head. The Lane-Wells pressure gun is next lowered to the cementer level and the gun ports set directly opposite the Cementer's frangible phosphor discs by means of the collar locator. Firing the pressure gun fractures the discs and allows mud to be circulated through the Cementer parts. The pressure gun is removed, the cement head replaced and cement is then pumped through the Dual Seal Cementer behind the casing and allowed to set. When the cement is drilled out of the casing, the upper stage job is tested with either a formation tester or by bailing before cleaning out to bottom. Economies effected by the use of this tool include the material and labor costs of running and cementing an extra string of casing, plus the time used by cementing the string at the bottom and the top in one operation.

LANE-WELLS COMPANY
DUAL-SEAL CEMENTER



TOMORROW'S TOOLS TODAY

JANUARY, 1939

Lane Wells Co.

411761

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O.G. FIG. ____
CLASS ____ SUB. CLASS

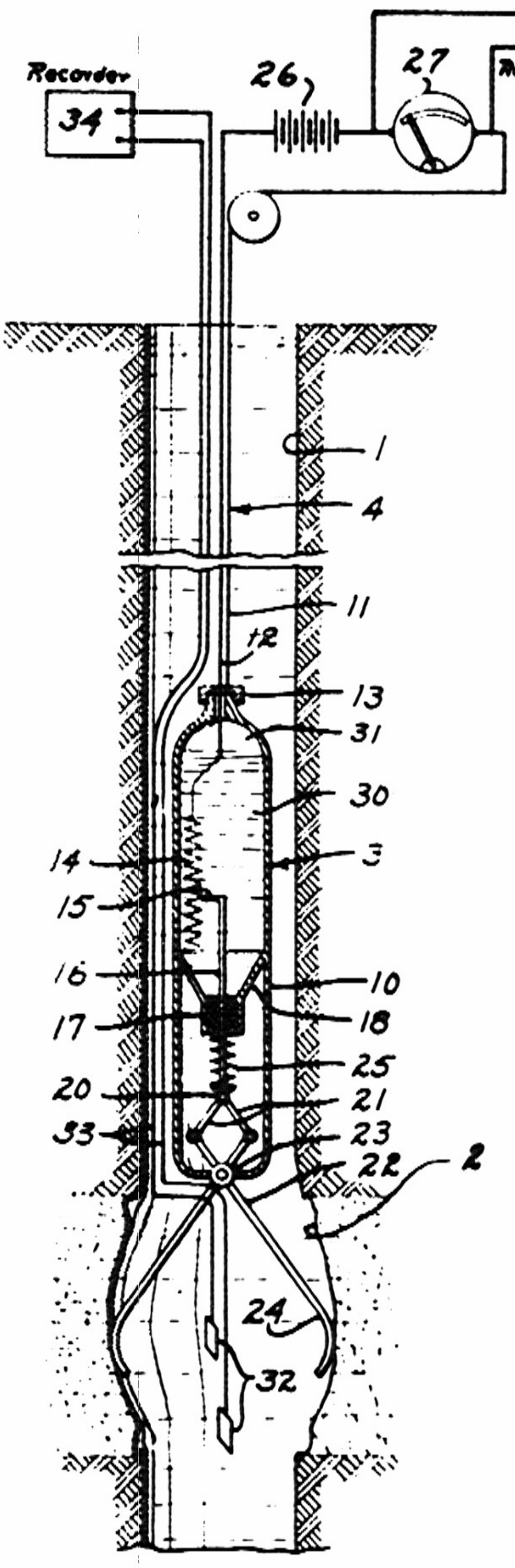

Fig. 1.

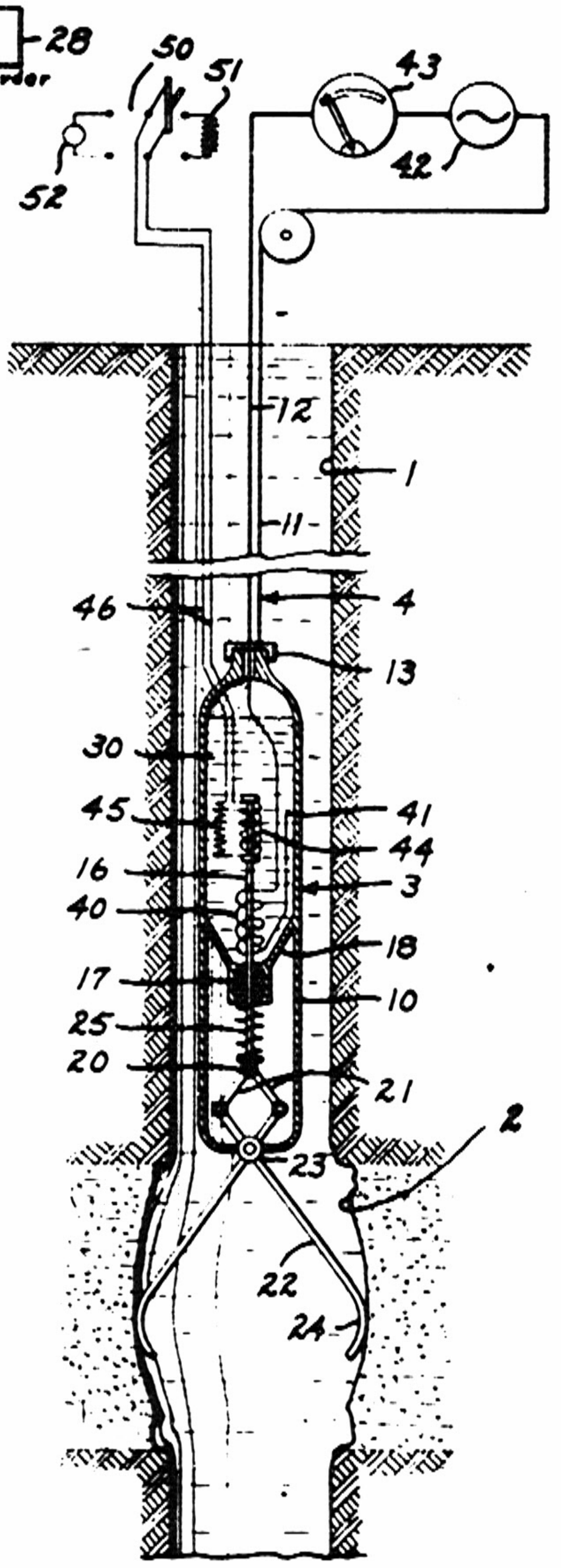

Fig. 2.

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INVENTOR.

BY Lester B. Clarke
ATTORNEY.

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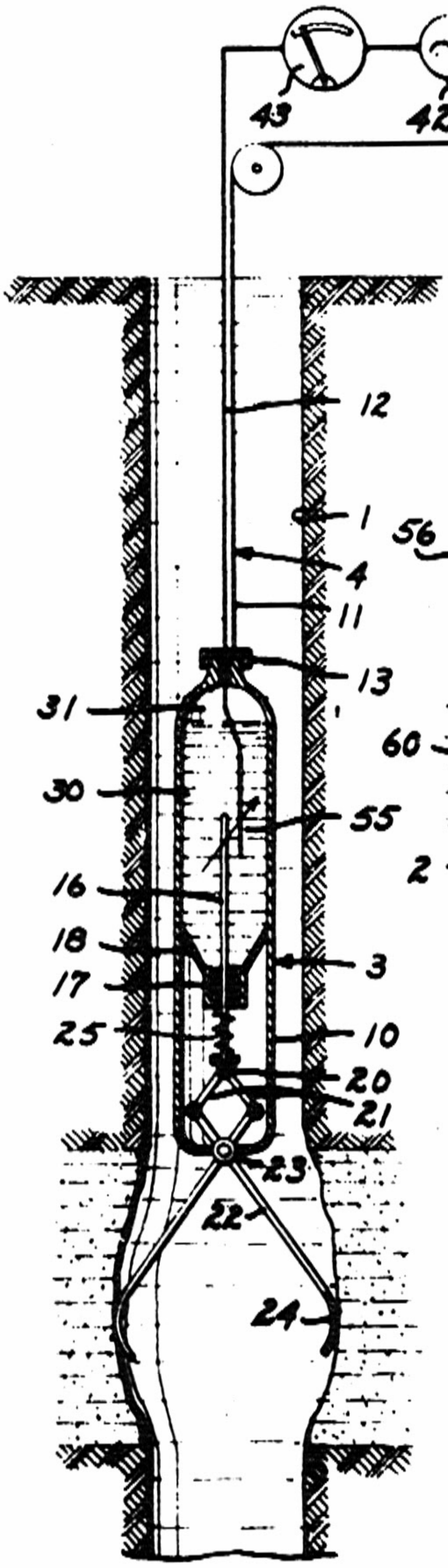

Fig.3.

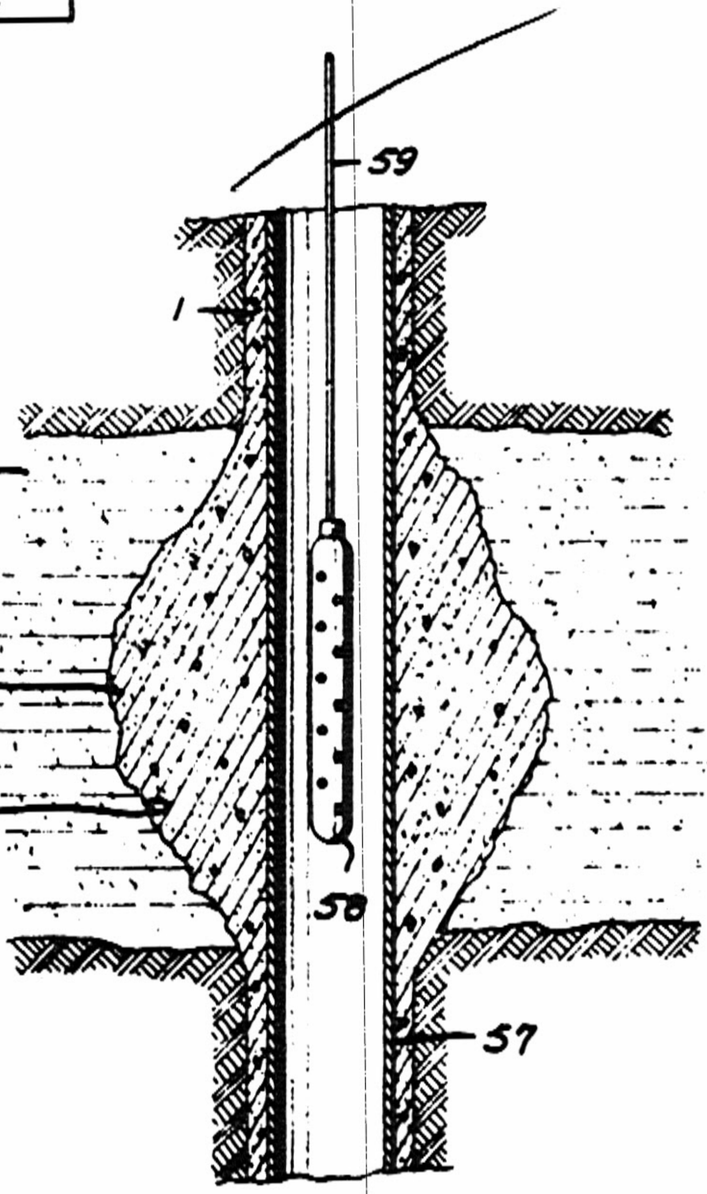

Fig.4.

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INVENTOR.

BY Lester B. Clark

ATTORNEY.